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OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

Volume 6 FEBRUARY, 1927 Number 2

ANNUAL MEETING

The Meetings and Papers Committee have made tentative plans for the coming Annual Meeting of the American Welding Society which will be held on April 27, 28 and 29, in the headquarters of the Society, 29 West Thirty-ninth Street. In order to meet the demands of the membership for more time to be given to papers it has been decided to distribute the matters usually coming before the business meeting among several other sessions. This has permitted the holding of two technical sessions, instead of one. The technical papers will include brief reviews by prominent experts on researches in the welding field made during the last three years and a symposium on welded products. Six or eight authors will give complete details including cost figures concerning some specific application of welding in production work. A Dinner Dance has been scheduled for the evening of April 28, at which time some novel features will be introduced. Every effort is being made to insure that this Annual Meeting will be an outstanding success.

STRUCTURAL STEEL

Several months ago a representative committee was organized by the American Bureau of Welding to carry out a series of investigations which would yield fundamental data needed by designers and engineers who contemplated the use of welding in this field. Mr. J. H. Edwards, Chief Engineer of the American Bridge Company, was selected as Chairman. On the committee are, welding experts, prominent structural steel engineers, representatives of fabricating companies, testing experts and other scientists.

A small subcommittee was appointed to review literature and existing information in order to give the industry and the committee a critical digest of such information as was now available. Another subcommittee laid out specifications for a series of test specimens that would yield the necessary design data, and a third subcommittee prepared specifications for welding procedure in making up these specimens.

It is planned to hold a meeting of the committee on February 21st in Philadelphia in order to review the progress made by these various subcommittees. Great enthusiasm has been displayed by all those interested. Through the courtesy of the American Institute of Steel Construction, a questionnaire was sent to their member companies and nearly 70 fabricating companies have indicated a willingness to cooperate by making up test specimens. Through contacts established by the Chairman, steel needed for the investigation has been promised by steel companies. The American Institute of Steel Construction has also indicated a willingness to contribute half of the thirty thousand dollars in cash needed by the committee according to its estimates. The welding industry is expected to contribute the remaining portion of the cash funds.

The possibilities of welding in this field are enormous. As soon as the fundamental data is secured engineers and the designing room staff will be enabled to specify the use of welding in the fabrication of structural steel. Of course, these applications at first will be confined to minor parts or places where the economies of the process are apparent. Later on, as experience is gained and confidence in methods established, the use of the several welding processes will be gradually extended.

BOUND VOLUME OF JOURNAL

The Bound Volume of the 1926 Journal is now ready for distribution. Each year a limited number of copies of the Journal are bound up in attractive book form together with an index. These are sold to members at $5.00

per volume and to non-members at $10.00 per volume.

A permanent record is thus made of the Society's activities and the most important papers presented before the various Sections and the meetings of the Society, as well as reports of the research department (American Bureau of Welding.)

IT IS THE DAWN

By W. L. FRANKLIN

(Communication to the Editor)

Selling the idea of welding is not quite so hard today as it probably was ten years ago. I wonder why? The interest with which the world at large is viewing welding is much more intense than it was ten years ago. There is more money being saved by welding in this country each year than the total amount invested in the welding apparatus with which this work is being done. It is but the dawn of a new era in the history of industrial development.

Can you allow your imagination to wander for a moment over some of the possibilities for welding and imagine what may happen in the future?

It is the eventide in the busy city and Mr. Cliff-Dweller has paused a moment on the street with his neighbor to view the building of a large apartment house across the street. The steel framework has risen rapidly and quietly. The members rise into the air silently, are swung into place and are fastened together by men with a peculiar bluish white flame which crackles like burning pine and throws off a shower of tiny sparks. There is no confusion, no noise, and no disturbance to the surrounding community. There is mystery here, and Mr. Cliff-Dweller is much interested. Here and there among the girders and uprights there is a sparkling flame with bluish white flare like a number of lightning bugs. The operators appear like dwellers from another world, grotesque and ungainly, but nimble and exceedingly active. Welding is being used for this construction. This silent motion is positively uncanny, but Mr. Cliff-Dweller is thankful that he can have a quiet night's rest and he enters the house unmindful of the years of labor and experiment which have made this possible.

In the shipyard, we pause for a moment astounded by the quiet activity around the several ships upon the ways. The exterior of the ship is smooth. The plates seem laid one upon the other and held together by some mysterious force. From the upper deck we look down into the hold and see a peculiar bluish white flash at times. There is a faint odor of ozone and slight crackling sound coming from the hatch. The hull plates are being welded to the ribs and the bulkheads are being welded to the framework of the ship. In fact, the entire ship is one complete piece of steel and capable of floating safely upon the sea.

In the factory and in other lines of human endeavor we find that little powerful bluish white flame being used wherever there are metals to be joined. It is no more a novelty or a freak but rather a necessity and a valuable assistant to the designer and builder. How times have changed!

At the present time, there are those who are afraid of welding because they know not what it is. They fear it for its mystery, its weird accomplishments and characteristics. And yet welding is a product of nature, a conversion of a natural phenomenon to practical use. We are now in the infancy of welding and are just beginning to see its possibilities. It is the dawn.

WELDING TO AVOID EMBRITTLEMENT

(Reprinted from the Dec. 28, 1926, issue of Power.)

When Alexander the Great found he could not untie the famous Gordian knot, he cut it with his sword. This old story and the proverb, "There is more than one way to cook a goose," might well be inscribed on the walls of every engineer's office. The good engineer is always a man who can find another way when the customary routes are closed.

These thoughts were inspired by a recent remark of Professor Christie. He was presenting his report as chairman of the subcommittee on embrittlement of boiler metal at the annual meeting of the joint research committee on boiler feed-water studies. As pointed out by Professor Christie, practically nothing is yet known as to the mechanism of the so-called "caustic" embrittlement. It *is* definitely known that embrittlement occurs and that in boiler practice it is found only in the riveted joints of drums. This being the case, said Pro-

fessor Christie, why not consider the possibility of cutting this Gordian knot by the use of drums fabricated without rivets, thus avoiding all trouble of this sort until further research makes other remedies available? In particular he suggested that it might be feasible to fabricate drums by welding, annealing the whole drum after the welding operration to release strains set up either by welding or the preliminary curving of the plate. While he did not specify the kind of welding, he apparently had in mind both forge and autogeneous welding.

In this connection it is worth noting that forge-welded boiler drums are now being made in Germany. Some of these, it is said, are hydrostatically tested to three or four times the working pressure. Such test, while stressing the metal beyond the elastic limit in some cases, proves the soundness of the weld. This point having been settled, the entire drum is annealed to relieve the strains set up by the test pressure. While Professor Christie himself made no mention of test pressures, this matter should be considered carefully in connection with welding and annealing.

It should be clearly understood that *Power* is not recommending the welding of boiler drums. The A.S.M.E. Boiler Code Committee, the recognized authority on boiler construction, has not yet seen fit to authorize their use. This position is justified until the safety of such drums, as made commercially, is established beyond question.

SECTION ACTIVITIES

New York

The February meeting of the Section was held in the Engineering Societies Building on the 1st. Commander Ellsberg presented a lecture on "Under Water Cutting," which was copiously illustrated by lantern slides. Among those discussing the address was Mr. T. F. Hagghind, Manager, Under-Water Metal Cutting Corp. This was practically the first presentation before the Society of reliable information on this subject.

The next meeting of the New York Section will be held on March 15. The meeting will be devoted to a symposium of papers on Resistance Welding. Every effort is being made to make this meeting an outstanding success.

Philadelphia

The February meeting will be held on the 21st and will be devoted to a series of papers on "Welding and Riveting in the Fabrication of Steel Structures." A meeting of the Structural Steel Welding Committee is scheduled in Philadelphia on the afternoon of this day and the plans of the Section are to make this one of the greatest meetings of the year.

Detroit

"Arc Welding of Structural Steel, formed the main topic of discussion at the February meeting of the Detroit Section. Mr. A. M. Candy of the Westinghouse Electric and Manufacturing Company, presented a review of the large and comprehensive series of tests made by his company to demonstrate the adequacy of welding in the fabrication of steel structures. Experience gained in the erection of the five-story all welded building at Sharon, Pa., was also reviewed. Nearly 200 people were in attendance.

The Detroit Section has devoted considerable effort in demonstrating the suitability of welding in this field. Several papers by prominent speakers have been presented on this subject. In addition, the Section has appointed a research subcommittee that has made a series of tests to convince local building inspectors, that welding may be used properly and with safety in this work.

Chicago

Mr. J. C. Lincoln of the Lincoln Electric Company, addressed the Section on Friday, Feb. 4, on the general theories governing the action of the metal arc in welding and illustrated his talk with sketches on the blackboard. A motion picture was also shown of "Arc Welding Applied to the Fabrication of Structural Steel."

San Francisco

The January meeting of this Section was held on Jan. 21 in the Engineers' Club. The paper of the evening was "Welding of High Carbon & Alloy Steels with the Acetylene Torch." This paper was prepared and presented by the Air Reduction Sales Company of Emeryville,

Cal. In addition, a description of the Martin County Pipe Line was given by the Brown Bros. Welding Company, as well as a description of other recent interesting welding jobs. Both of these talks were illustrated by lantern slides.

The February meeting of the San Francisco Section was held on Feb. 11. Mr. W. F. Barron of the Linde Air Products Company presented a review of Oxy-Acetylene Welding of Steel Pipe Lines. A motion picture film was shown, entitled "Procedure Control for Laying of High Pressure Steel Gas Mains." This picture showed the various steps on a typical pipe line job, including trenching, lining up, tacking, oxwelding of joints, soil-proofing, testing, etc.

Western New York

Mr. A. V. Harris, Dist. Sales Manager of the Haynes Stellite Company, presented a paper at the Feb. 15 meeting of the Section, entitled, "Surfacing of Steel and Cast Iron with the Alloy called Stellite." Demonstrations and Applications of this product were also made.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be addressed to the number indicated in each case and mailed to Society headquarters.*

SERVICES AVAILABLE

A-51. All around Oxy-Acetylene and Electric Welder desires position. Have had 10 years' experience as oxy-acetylene welder and three years' experience as electric welder. Have worked for National Sugar Refining Company and Fletcher's Ship Yard.

A-52. Oxy-Acetylene and Electric Welder desires position. Have worked on high pressure water boilers, stills, pipe lines for over five years. Capable of handling all sorts of repair work.

A-53. Electric Welder desires position. Have had eight years' experience in general repair and production work, including two years of own business. Can submit references.

A-54. Oxy-Acetylene and Electric Welder desires position. Have had six years' experience as oxy-acetylene welder on pipe work, boiler work and repair work. Fully experienced to qualify for a position in any branch of oxy-acetylene welding. Also one year electric welding on boiler work.

A-55. Welder desires position. Have worked for the following firms: Erie Railroad, New York, New Haven & Hartford Railroad, Electric Welding Company of America, Pioneer Iron Works, Gulf Refining Company, Leonard Construction Company. Have been in the employ of the Electric Welding Company of America since 1919.

A-56. Experienced welder desires position. Have had eight years' experience as an Oxy-Acetylene Welder of steel, cast iron, and brazing. Have worked for the Hoist & Body Company, Columbia Machine Company, Link Belt Company, Baker Iron Works and Southern Pacific Company. With each of the three latter companies I have worked from two to three years.

Pipe Line Welding from the Oxy-Acetylene Viewpoint*

LE ROY EDWARDS†

During the last few years there has been a growing demand for a perfectly satisfactory method of joining sections of pipe together and a great deal of attention by engineers has been given to the solution of this problem.

Among the advantages resulting from oxy-acetylene welding as applied to pipe line construction are:

Permanence of joint. A welded joint is of the same metal as the pipe and will last as long as the pipe itself without additional maintenance. Strength of welded joints closely approximates the strength of the material in the pipe, and the strength when properly made is much greater than that of screw fittings and some other types of construction.

The whole line to all intents and purposes becomes practically one length of pipe.

Welded lines facilitate the transfer of liquids and gases because of the higher pressures which can be safely carried with less friction losses than screwed or bell and spigot joints. This method of construction is very economical, comparing favorably with the cost of screwed joints and with a greater freedom from leaks. In case of leaks the welds can be repaired in place without taking the line apart which is almost impossible with screw joints.

The portability of equipment is greatly in its favor as lines can be constructed in any kind of country through which the material can be transported. This process also has the advantage due to less weight of material used in its construction than in cast iron pipe lines, and because of its great tensile strength it is largely able to resist the expansion and contraction stresses due to changes in temperature.

Welded steel pipe lines are being used to replace many cast iron bell and spigot lines, where in many cases it would be necessary to put in piling or other forms of foundations for support, due to the weight of the pipe or conditions of the ground where it is laid, or on account of vibration and shock peculiar to the locality. Because of the long lengths of steel pipe available for welded lines combined with the high tensile strength of the joint, it is generally unnecessary to put in foundations, except for elevated sections, as the line after it is welded is sufficiently strong and flexible to stand shock and vibration without injury.

The oxy-acetylene welded joint with complete penetration and with a suitable reinforcement will have strength equal to that of the parent metal in the pipe. There is also an advantage in hav-

*Paper read before New York Section, American Welding Society, December 21, 1926.
†Industrial Engineering Department, Air Reduction Sales Company, New York.

ing a continuous line without obstructions at each joint to cause friction and allow pockets where sediment may collect as is the case where screw couplings are used.

An oxy-acetylene welded line is sufficiently flexible to follow the

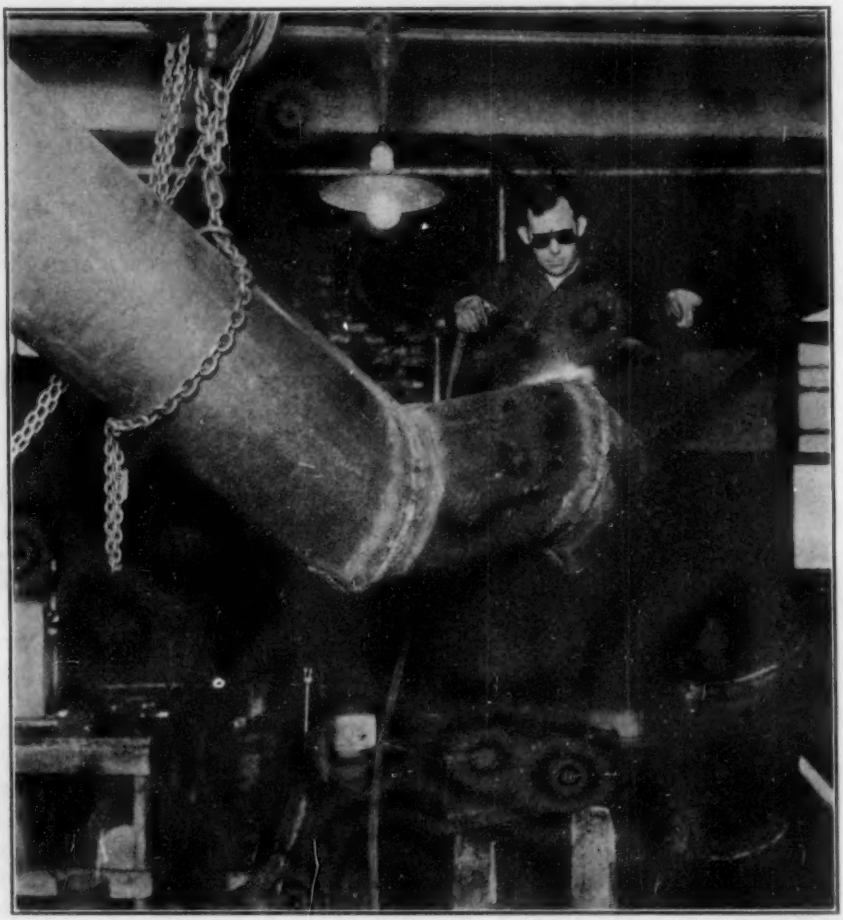

Fig. 1. Welding an offset bend of 16-inch pipe sections cut from stock pipe.

contours of the surface of the ground and bends easily to a long radius without being obliged to make any special provisions. Welded pipe can be bent to quite short radii when necessary without injury to welds, and bent pipes that are difficult to assemble with unions and flanges may be joined by welding without any trouble, thereby saving the cost of expensive fittings.

The use of special fittings is very costly and usually avoided when possible. In case these fittings are made of cast iron or cast steel it is necessary to have patterns or sweeps made before they can be cast, and weeks may elapse before satisfactory castings

are received from the foundry. After that it may take some time for them to be machined for use. The oxy-acetylene welding torch in conjunction with the cutting torch and a few templets are all the tools necessary for the making of almost any type of fittings. This work is generally done as the line progresses and the exact pattern of fitting is determined. The fittings made in this way are quickly produced, are much lighter, and, therefore, more easily handled than a cast fitting or a combination of cast fittings.

One of the larger gas companies supplying an extensive territory that has been welding pipe for several years, has worked

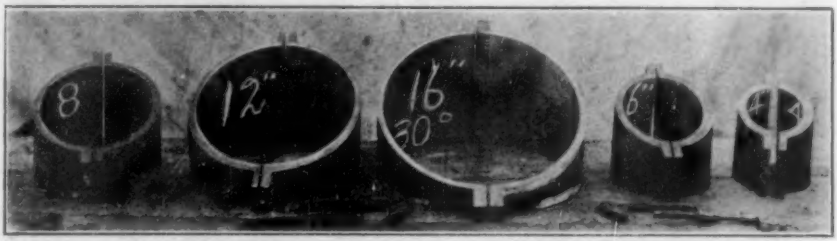

Fig. 2. Cast iron templets for marking off standard pipe used in making up bends and other fittings.

out a very satisfactory plan to meet its ordinary requirements of standard fittings. Various kinds of standard fittings have been designed to be welded from steel pipe. Standard dimensions have been adopted for each fitting. The fittings consist of elbows, tees, offsets, reducers, crosses, manifolds, saddles, Swage nipples, Dresser caps and such other fittings which have become standard in their service work. In order to facilitate the making of these fittings they have constructed cast iron templets, as shown in the illustration. These templets are attached to the pipe by "C" clamps and the piece to be cut is either marked off with a soapstone pencil and the clamp removed for cutting, or by using the side of the clamp as a guide for the torch in making the cut. The clamps are split on the inside and outside center lines, and before the clamp is removed after marking or cutting these center lines are transferred to the section to facilitate assembling the joint. These fittings are made up during slack periods or days when the weather does not permit of working outside, thereby keeping a contented welding crew available for all emergencies. This system has a great many points in its favor, the most important of which is that fittings of a standard size can be ordered from stock, as shown on this company's blue print, thereby saving valuable productive time when the pipe line is being laid as the time it takes to lay out and weld up a fitting under field conditions may be sufficient to weld several lengths of pipe. What the concern laying the pipe is most interested in is the completion of the pipe line in the shortest possible time. Therefore, any work which can be

performed in another place at a more convenient time is of great assistance toward the completion of the pipe line on schedule.

When these fittings are made in the shop the accumulation of short ends of pipe can be utilized for this work, thereby turning into production material which might otherwise be thrown into the junk pile.

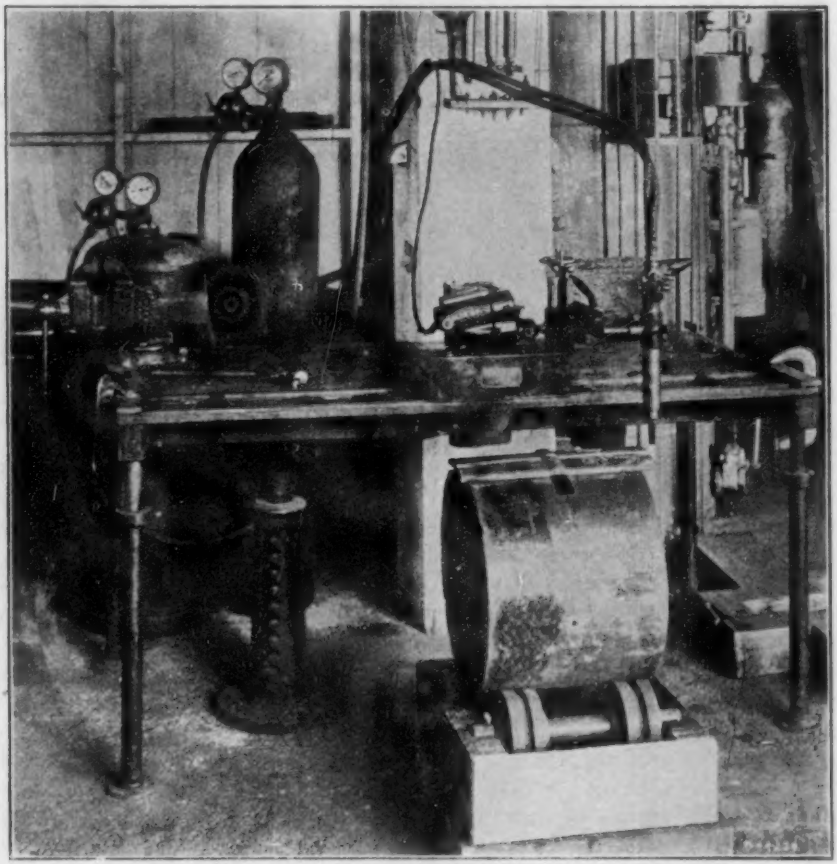

Fig. 3. Cutting a large diameter pipe weld into test strips with the Radiagraph.

There are seasons of the year in the greater part of this country when it is impossible to carry on outside construction, and most companies are obliged to lay off the welders they have spent many days or weeks to train in their methods of operation. This idea of making up stock fittings has given steady employment to these welders the year around and is a means of keeping down the labor turnover and reduces the cost and need for training new men when the season opens. There is another point of interest to employers and that is that seasonable work demands high wages while steady employment enables employers to have and hold

those men at a fair wage whom they have trained to appreciate the responsibility of their labors.

Saving of time by laying lines by the oxy-acetylene welding process has been found to be greatly in its favor.

In lines joined by screw joints only one section is joined at a time, while in a welded line as many lengths can be joined as there are welders available which may involve several hundred feet of pipe.

An instance of this is a case where 50 miles of 10-in. pipe line was welded and laid through a series of towns in 45 days. In this case the pipe was welded faster than three trenching machines were able to dig, the machines working 24 hours per day.

Records like this require a trained organization and competent

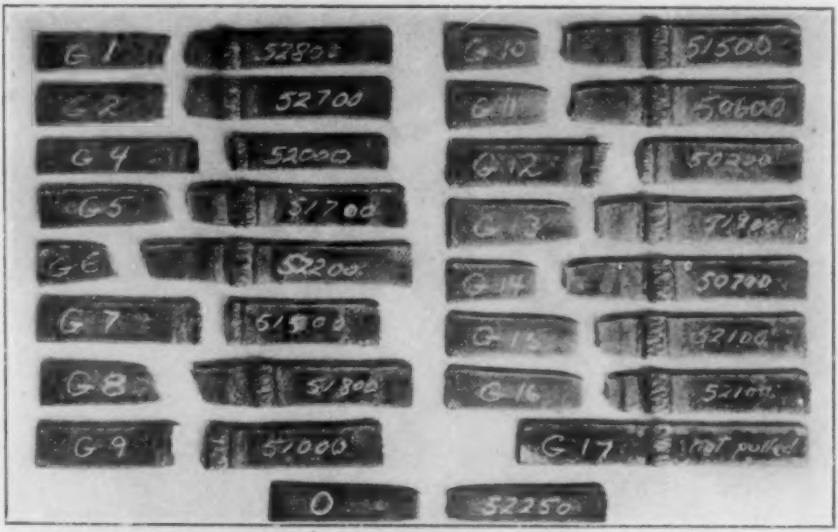

Fig. 4. Tensile strength of test pieces cut from pipe weld.

welders interested in producing the largest number of welds per day.

There are many other reasons than those described why the oxy-acetylene welding of pipe lines is very desirable.

While the process is not at all new to pipe welding, it having been started over fifteen years ago, the service rendered by the early oxy-acetylene welded lines have proven the practicability of this method, and it is this very enviable record which is the reason for the tremendous present-day activity along these lines. Oxy-acetylene pipe line welding has proven practical and economical and at the same time permits speedy construction under all conditions.

Preparation

In considering the installation of a pipe line it is very necessary that attention be paid to organizing a personnel to handle the field

operations so that a careful check can be made as the work progresses and thus insure good workmanship and speedy construction at all times. In making welded joints certain dependence must be placed on each individual welder, and for this reason the welders should be carefully trained and made thoroughly familiar with pipe line welding.

Special attention should be given the selection of welders. Each man should have impressed upon him the seriousness of his operations. It is considered advisable, after a man has proved

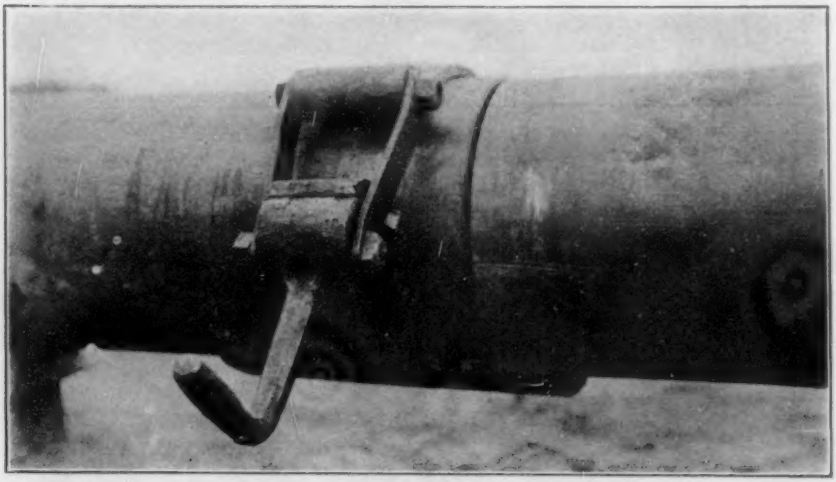

Fig. 5. Device for holding pipes in line while tacking.

his ability as a welder and before he is allowed to weld on a pipe line carrying high pressure, that he should be required to more fully demonstrate his ability on one or more test pieces, made by taking short pieces of pipe, and, after tacking and supporting them about 18 in. above the ground, make a complete weld without turning the pipe. After this weld has been made it should be cut into strips about 2 in. wide and each strip should be tested by placing it in a vise with the edge of the weld even with the top of the jaw of the vise and with the outside of the weld toward the operator. By using a clamp on the upper part of the test piece it should be bent so that the bending strain is localized on the inside of the weld, which ordinarily is the weakest part of the joint. A good oxy-acetylene weld will withstand this test when bent 180 deg.

This method of testing is suitable for field tests, but does not compare with the tensile tests, which will be described later, as a means of determining the value of the welders and their work.

Particular attention should be given to determine if the under- or over-head welds are as good as those on top. If the work of the welder is satisfactory on one or more tests of this kind, it can

be considered safe to allow him to weld on the pipe line. If his work is not, but shows promise or ability, he should be put through a course of training until he is able to make satisfactory welds. If this procedure is followed the men will understand that perfect work is expected of them and will continually strive to maintain quality.

It is customary for concerns or contractors who are doing the

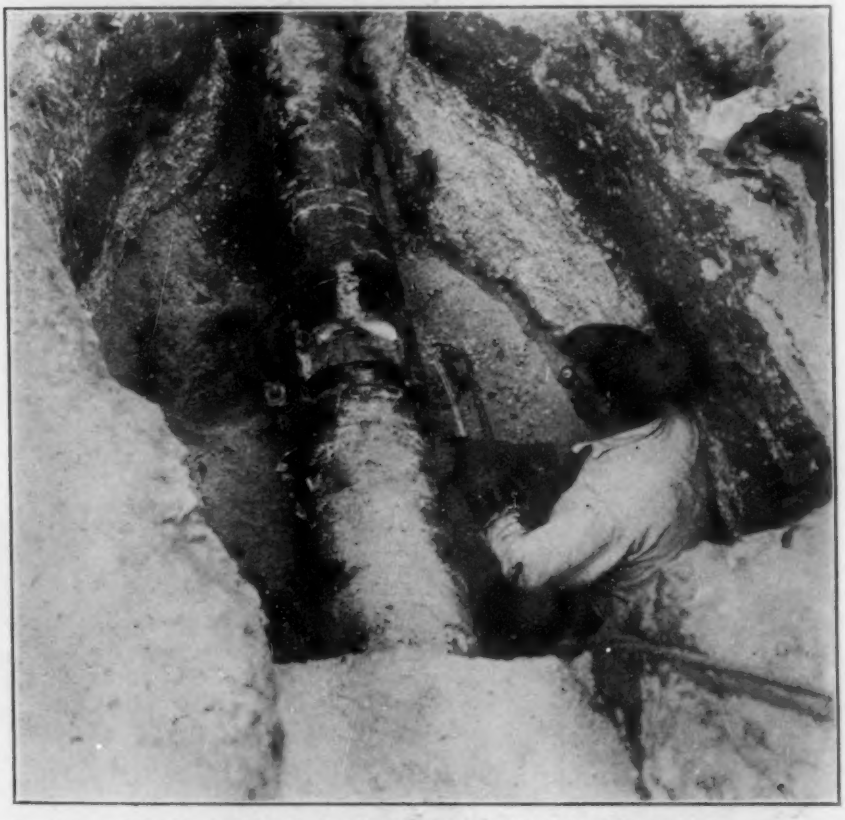

Fig. 6. Another device for holding pipes in line while tacking.

highest class of work to have in their employ one or more leading welders who are capable of instructing apprentices, or deciding on the qualifications of new employees, this instruction carried on until the operator is able to comply with the above mentioned test and make welds of standard quality.

A method of testing welded joints, which has had the approval of engineers and contractors interested in doing the highest grade of welding, is to take a full section out of the line, about 18 in. long, with the weld in the center. This section is then cut into longitudinal strips, about 2 in. wide, by the use of a radiagraph, which is a motor-driven machine carrying an oxy-acetylene cut-

ting torch, each strip being numbered consecutively around the circumference of the entire section. The strips are then put in a testing machine and pulled to determine the tensile strength of the weld. A sample of the pipe is also procured, cut and tested in the same way for comparison. The results of a specimen test of this kind will give a definite idea of the strength of the welds

Fig. 7. Making tie-in welds.

which are being made and further give a figure for the average strength of the entire pipe joint.

A standardization of all torches, regulators and equipment used on the line is very desirable because it facilitates maintenance and insures uniformity in procedure, because all welders can operate under exactly the same conditions. In other words, by standardi-

zation of equipment, tip sizes, pressures, speed of operation and methods of welding, the kind of joint produced can be absolutely controlled and the result is evidenced in more economical and more satisfactory welding.

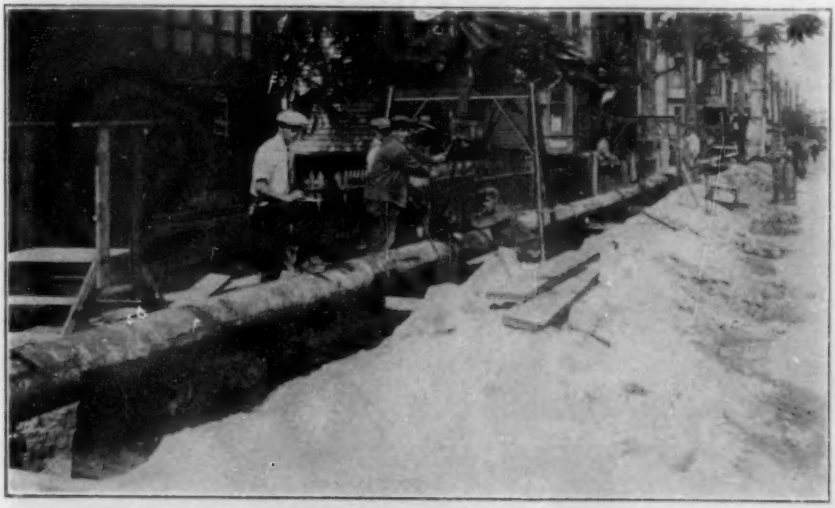

Fig. 8. Lowering pipe line into trench with slings, chain blocks and other apparatus.

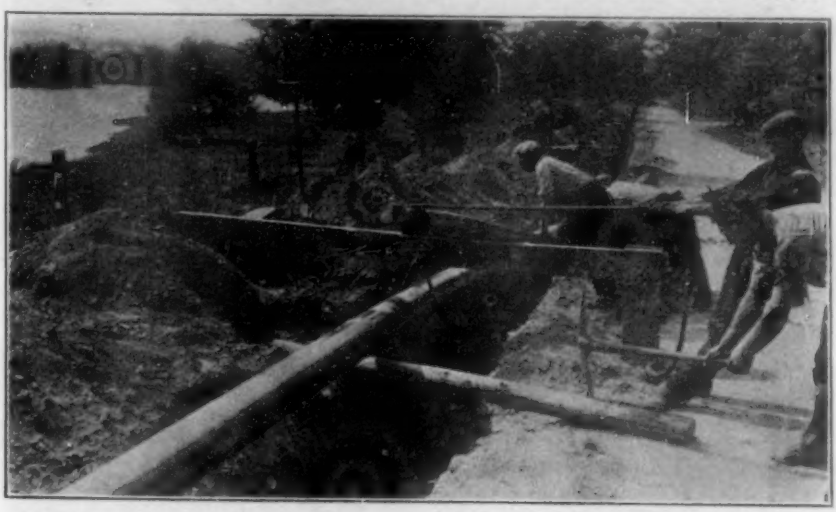

Fig. 9. Illustrating use of lever and rope sling for easing pipe line into trench.

A high grade of welding rod should be used because the strength and uniformity of the weld depends to a very considerable extent on the material which goes into it.

Material

In some parts of the country the condition of the soil is such as to cause rapid corrosion of steel pipe.

Soil conditions, where the line is to be laid, should be the determining factor as to the desirability of employing soil proofing. The usual method of applying soil proofing is to dip or paint the pipe with a bitumastic coating, and if soil conditions are unusually severe the pipe should be wrapped with burlap, or one of the various grades of roofing paper which offers the best protection for that particular soil condition. When wrapping is resorted to, it is usually done when the bitumastic coating is hot.

Fig. 10. Spanish windlass for easing heavy pipe line into trench.

After the welds have been made and tested, the exposed portions are then wrapped or coated to produce uniform conditions.

The ends of the pipe should be chamfered to an angle of about 45 deg. to within 1/16 in. of the inside edge of the pipe.

The nearer the beveling toward the inside edge the easier it is to get complete penetration, and we all know that pipe in perfect alignment, welded all the way through, is much stronger than that welded with partial penetration.

Aligning of Pipe

Next in importance to the welding operation is the care and attention required in the aligning of the joints in order that perfect welds can be produced economically.

There are various methods of aligning pipe and the method selected depends a great deal upon the conditions where the pipe is to be welded and laid.

Many concerns favor supporting pipe on timbers, blocking up so edges are in proper position and so that it can be rolled while making the weld. This method is very satisfactory. Others prefer cutting a "Vee" in blocks so the pipe can be revolved without being thrown out of line. In other cases a pedestal block with two rollers is used. This, of course, reduces a great deal of friction in the turning of the pipe. All of the above methods are found to

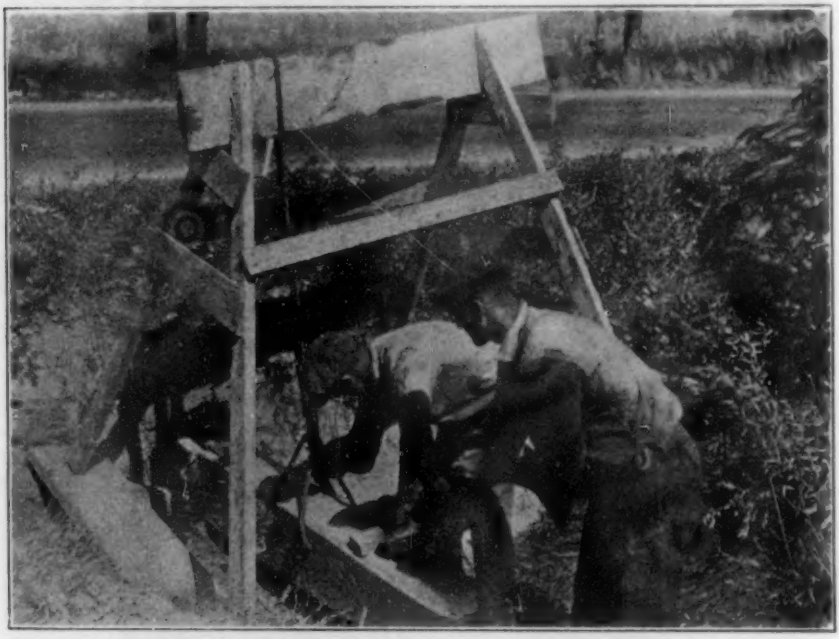

Fig. 11. Driving pipe bit under highway to tunnel for pipe line.

be very satisfactory and are commonly used on piping 10 in. and smaller.

There are devices which have been developed which are of considerable assistance in holding the pipe in line during the tacking operation.

One device consists of a lower member cut from steel plate and bent to the radius of the pipe which extends beyond the end of the pipe to which it is attached. This extension forms a support for the adjacent pipe, while the exposed portions of the joint are welded. This bottom member is quickly adjusted to the pipe by a series of links to which it is attached on one end with a cam on the other end, which engages with a curved lip on the bottom member, forming a linkage which provides rapid adjustment.

The handle attached to the cam affords sufficient leverage to

draw the links firmly together and raise a heavy pipe into proper alignment.

Another device frequently used is made from a pair of pipe clamps, to each half of which bars have been welded. These bars extend a few inches beyond the side of the clamp, and near the end of each bar on the upper half of the clamp holes have been drilled and tapped for set screws which are used to attach the

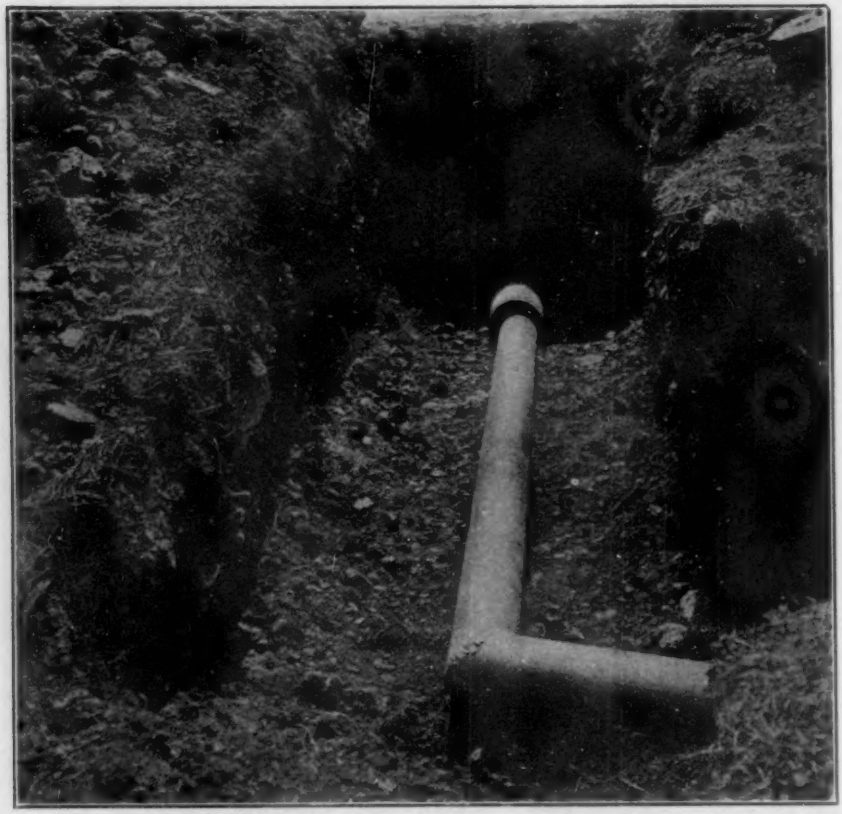

Fig. 12. Pipe line threaded through pipe driven underneath roadway

clamp firmly in position with the bottom section in close contact with the pipe. The adjoining length of pipe is, therefore, quickly and accurately positioned for welding.

It is obvious that any scheme for quickly positioning the joints so that the edges are in proper position will facilitate the welding operation and assist in producing more satisfactory welds.

Methods of Laying Pipe

Where it is possible to have fairly straight runs, it is advisable to make all possible welds on the surface, either alongside the trench or over the trench, with the pipe supported on timbers. The pipe can then be lowered into the ditch, where it can be tied

on to the main line by excavating a bell hole and making a tie-in weld.

On small pipe lines a tie-in weld may be made on the ground alongside of the trench, or while the pipe is supported on timbers over the trench, and on account of the flexibility of the pipe and the strength of the gas welded joints the pipe can be lowered into the trench progressively.

As this type of weld is made more slowly than a weld made by

Fig. 13. Marking pipe line welds to fix responsibility of welder.

rolling the pipe, it is advisable to have the sections welded in the longest possible lengths because this is a one-man job, whereas when the pipe is being rotated several men can weld simultaneously on the same section which may consist of many lengths.

Lowering Pipe in Ditch

There are several methods used in lowering pipe into the trench. One that has proved quite satisfactory in the case of heavy lines is as follows: Portable steel horses to which are suspended chain blocks and slings are placed in position after the completed section of welded pipe line has been placed over the trench, supported on timbers, and made ready for lowering. The slings are then attached to the pipe line and the chain blocks are used to lower it into the trench.

Another method is by the use of a lever with a rope sling. The

operation is performed by having a supporting horse used as a fulcrum and a lever to which a rope is attached to the short end. This rope is led around the pipe and two or three turns taken around the end of the lever to be used as a snubber. The lever is then used to raise the pipe off the supporting timbers, and as the rope is released the pipe is lowered into the ditch. By the use of this system it is necessary to have more labor available for

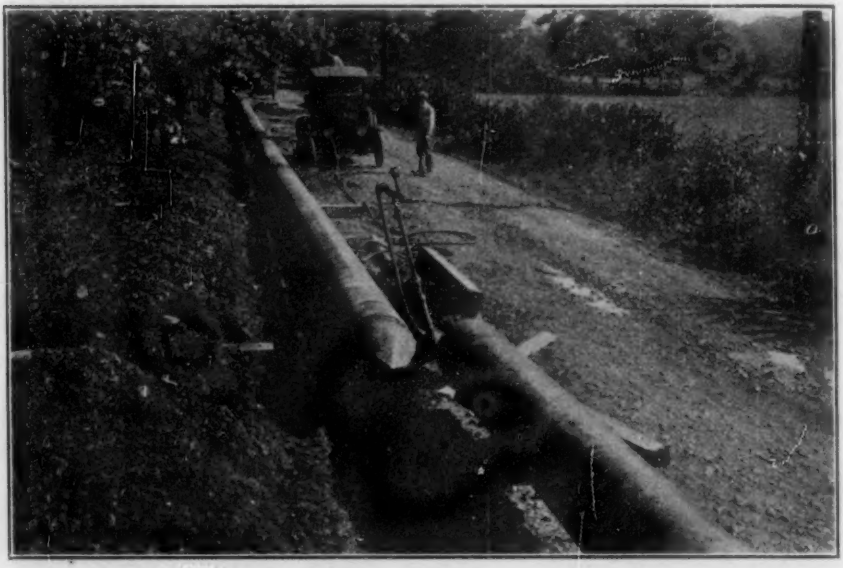

Fig. 14. Torpedo head closure welded to pipe line for testing.

a short period of time, but this has been found to be quite rapid and satisfactory on the smaller lines.

A method which has been successful on heavy lines is by the use of heavy timbers supported on the ends and extending over the pipe trench. These timbers have either been turned at the center or the sharp edges knocked off the corners to prevent chafing of the rope. The end of the rope is then attached to the timber with two turns and then knotted. The other end is led around the pipe, then three or four turns taken around the timber so that the strains on each supporting rope are on opposite sides of the timber. The lever is used to raise the pipe off the sleepers which are then withdrawn. The pipe is allowed to settle into the supporting rope. The turns around the timber are used as a snubber for lowering the pipe in the ditch.

There is a handicap at times through being obliged to lay a pipe under a street that has been newly paved and the authorities will not allow the pavement to be broken. This has been done successfully by the use of a bit which has been cut on the ends into saw teeth, the ends of which are protected by welding on tool steel or alloy steel to form a hard cutting edge. The trench excavation

is then made to the edges of the roadway and this bit is then driven through with some type of a battering ram. A pipe duct is then inserted in this opening and the welded pipe line allowed to pass through this.

Testing of the Line

In the laying of pipe lines in populated areas it is generally customary to weld and lay the line as quickly as possible, not only on

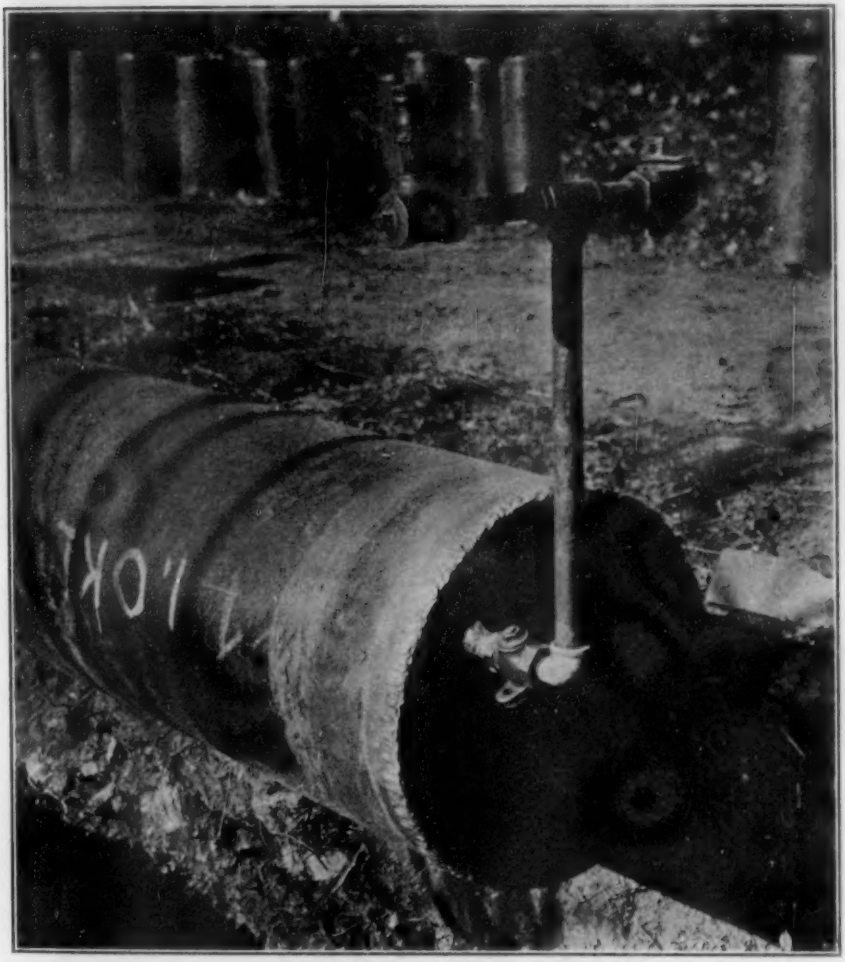

Fig. 15. Pipe line closure made with flat disc welded on for testing.

account of the hazard of having an open trench along the highways, but on account of the authorities who issue permits for the laying of lines, insisting that the streets be opened, the line laid and the street closed within a specified time. Sometimes not over twenty-four hours is allowed.

Marking of Welds

In the welding of pipe lines it is customary to employ a system whereby the work of each welder can be identified at the time of test and, in fact, until the line is in the trench and ready for covering. This point is sometimes overlooked as being of no great consequence.

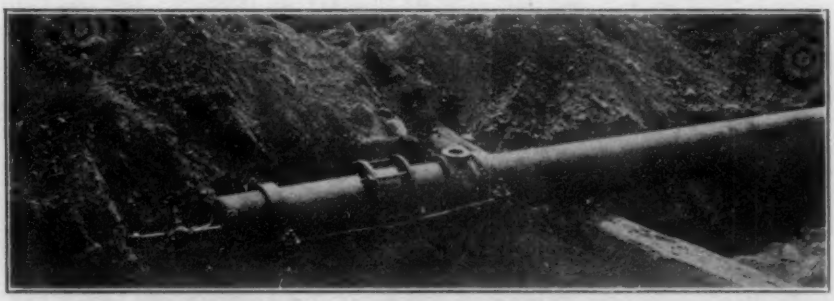

Fig. 16. Pipe line sealed by means of dresser coupling for testing.

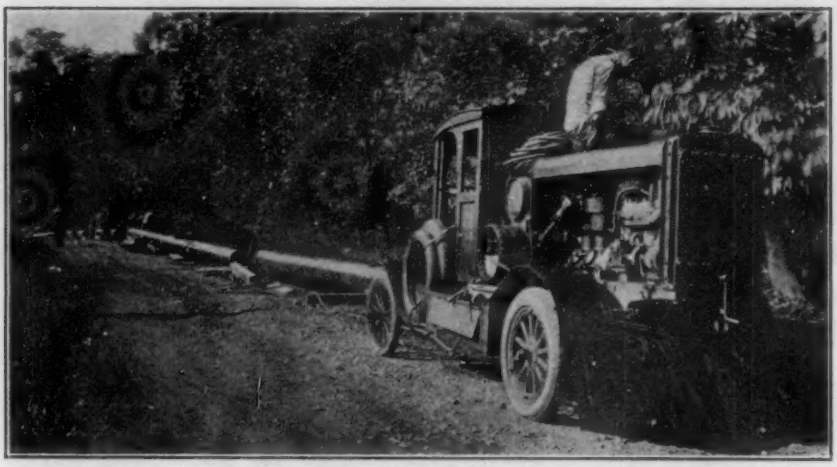

Fig. 17. Portable testing equipment

There are various methods of marking pipe. Some use a steel stamp, each letter designating a welder; others use a characteristic mark which is made by the welding on of metal from the filler rod next to the joint; others use paint for marking the initials of the welder next to the joint. This latter system of marking is not permanent, and it is sometimes advisable that the mark designating the welder should be a permanent record.

Expansion and Contraction

Welded pipe lines laid in trenches at a reasonable depth below the surface of the ground are subjected to comparatively small temperature variations, and it is, therefore, ordinarily unnecessary to provide for expansion and contraction as slight curvatures

up and down and sideways are usually enough to take care of the slight expansion changes which occur during the various seasons of the year. However, it is necessary at times to use expansion joints, particularly on long perfectly straight lines, or lines installed to handle steam or hot liquids and gases, or where the lines are exposed to atmospheric conditions as the increased variation in temperatures causes a much greater expansion and contraction for which the necessary provisions must be made.

Expansion joints are made in various types, such as long slip joints which consist of a long section of pipe with a smooth machined surface which is inclosed in a large section of pipe with

Fig. 18. Testing pipe line with portable air compressor equipment.

some form of stuffing box on the end. This will allow the entire section to move in or out without the serious loss of pressure.

Another type which is used quite extensively on some lines is a large "U" bend which can be welded in the line at the proper location.

Another type is a coil made by bending pipe in a complete circle. This method is only used on small pipe lines where leakage from the ordinary expansion joint could not be tolerated.

On the installation of valves on pipe lines, expansion joints should be provided for the protection of the valve, and especially if this valve is made of cast iron. The expansion joint placed on one side will be sufficient to protect the valve from the strains set up by the expansion of the lines. This is particularly true if the usual valve box is installed.

Methods of Closing Pipe Line for Testing

Various methods are used to close the ends of completed sections of pipe lines preparatory to applying the required pressure test.

One method commonly used where the test pressure is high is to make a torpedo-shaped head which is welded to the end of the

pipe line, and after satisfactory test has been made this end is cut off and used again for the next test. Another type is to weld a disc on the end of a short piece of pipe of the same diameter as the pipe line to be tested, and this section is welded onto the pipe line as was done for the torpedo type of head.

Still another method used for applying the two mentioned heads is to attach them by the use of a Dresser coupling, and fastened to the pipe line by special clamps on the pipe and head which are connected by bolts to prevent the head from being blown off during the test. This type of coupling eliminates the welding operations and leaves the end of the pipe in condition to weld without any further preparation.

Another type of head which is commonly used is one made from a Dresser coupling in which a disc has been welded to one end of the sleeve and the other end of the sleeve left open to be slipped over the end of the pipe to be tested. The sleeve is drilled for about 8½ in. set screws which, when screwed against the pipe line, prevent the head from blowing off when the pressure is applied.

It will be evident that neither of the last mentioned methods is applicable when high pressures are specified.

There are several methods in use for this testing. The hydrostatic pressure with a hammer test is probably the most severe. This is made by pumping water into the line at a specified pressure, being sure to displace all air and hammering the pipe adjacent to the weld. The impact of the hammer blows causes the vibration to travel through the pipe, and any weak joints will generally show up under this treatment.

On account of the inability to get a sufficient water supply, also the difficulty of drainage, this method is seldom used. In the case of high-pressure water lines this test is very desirable before the lines are turned over to actual service.

The method commonly employed in testing at ordinary pressures is by the use of air pressure and applying a mixture of soap and water which is painted over the joint, and in case of a leak it will indicate itself by the air bubbles which form on the outside of the joint. This test is extensively used and has been found to be quite satisfactory.

Several important points to be considered in the construction of gas welded steel pipe lines have been touched on in order to indicate the need for careful planning so that satisfactory construction can be expeditiously accomplished.

The use of steel pipe lines is still in its infancy. On account of the tremendous demands gas companies, public utilities corporations, power plants, oil and water companies and others interested in pipe lines that must be tight, and of low installation and maintenance cost, are turning to gas-welded steel pipe lines, as they more effectively meet the demands of the consumers.

Oxy-Acetylene Welding Steel Plate

T. C. FETHERSTON†

As a man's experience with oxy-acetylene welding increases, he will find that welding mild steel becomes one of the easiest things he has to do. Technique for this work grows almost to be instinctive and the operator will make strong, sound welds, hardly knowing exactly how he does it. Those who have had less experience with the blowpipe sometimes find that they fall just short of the results expected. It is usually found that this is the result of missing one or two of the minor essentials so necessary to a perfect job. It will pay every welder once in a while to check his methods very carefully. If he is regularly making good welds he can be sure of this fact, and can maintain high quality or even better it. On the other hand, if he is not satisfied with the welds he produces, he can discover and correct the faults that are responsible.

Often the comparative simplicity of mild steel welding causes the minor difficulties. The feeling develops that this is such a simple operation it just "does itself." If good welding requires anything, it is care and thorough workmanship; when either of these two factors is neglected the result is disappointing.

Two major factors are important in welding on steel plate and shapes just as in all oxy-acetylene welding: fusion and penetration.

To explain these in simple words, the term "fusion" indicates the thorough mixing of molten metal from the sides of the joint and from the welding rod. Its undesirable opposite is the melting of welding rod on relatively cool and unfused edges of the base metal. The latter is not a true weld and the joint will have little strength. To obtain thorough fusion, the operator must be certain that the base material is actually molten and flowing freely before he begins adding welding rod between the edges to be welded. He must then be careful that weld metal from the rod is also thoroughly molten as it is added. This is generally accomplished, as will be explained later, by melting the welding rod in a puddle of molten metal.

By "penetration" is indicated the careful welding of pieces to be joined the entire way to the bottom of the space between the edges, clear through to the underside. Combat the tendency to melt down the top edges and allow this metal to flow together, bridging over the lower space without working the flame down all the way to the bottom. This effect is avoided by working carefully from the bottom up and being sure that the edges are thoroughly fused every bit of the way. We shall see later how this can best be done.

†Linde Air Products Co.

Success in welding on mild steel is dependent to a high degree upon the selection of proper welding rod. High quality rods applied by experienced operators to steel of firebox quality will produce welds that will be stronger than the original plate. The main point in this for most operators or for men who are responsible for welding work, is that best quality welding rod is highly desirable; it is false economy to save a few pennies by compromising quality in the finished work. To use cheap rods of inferior quality or picked-up material not specifically formulated and manufactured for oxy-acetylene welding is to gamble with the success of the finished job—with the chances all against good work.

Another matter that is worth careful attention is preparation of the material to be welded. This involves three separate phases:

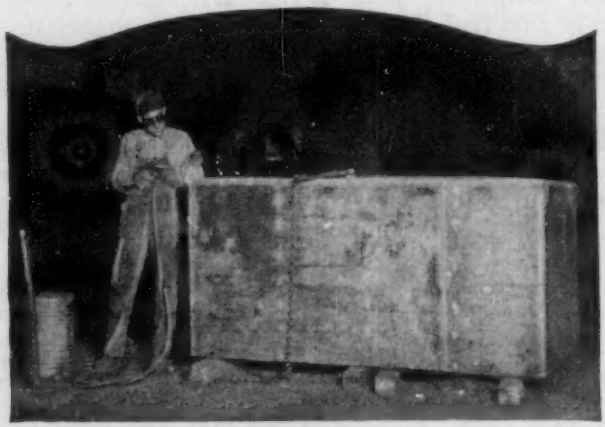

Fig. 1. Square tanks are built from steel plate

first, properly designing the welded joint, second, cleaning the edges of rust and scale, dirt, paint or other foreign matter; and third, beveling or veeing the edges so thorough penetration can easily be obtained.

The matter of designing the joint is a subject on which much could be said, especially on those phases of design relating to the position and type of joint with respect to the stress to which the weld will be subjected in use. It is sufficient to say here, however, that for most purposes the butt type joint, which is a joint in which the edges to be welded are brought together either in the same plane or in planes at an angle, is usually preferred over other types. Lapped joints are undesirable, especially where such a joint can be welded from one side only.

Butt joints in steel plate can be of either the single-vee or double-vee type. While some work is of such nature that it would be difficult or impossible to weld from both sides, it is usually best where maximum strength is desired to employ the double vee. This has several advantages, especially on heavy plate. The weld

can be reinforced on both sides, for one thing. Less time and welding rod are required than for single-vee welding in the same thickness of metal. Single-vee welds are usually employed on metal less than $\frac{3}{8}$ in. thick.

On metal lighter than $\frac{1}{8}$ in., or 11 gage, the edges are rarely beveled at all. The parts are simply brought together and welded either with or without addition of metal from the welding rod, depending upon the extent of reinforcement desired. Light gage sheet metal is often flanged slightly, the two flanged edges being put together and welded without addition of welding rod.

Fig. 2. Making a practice weld

When welding steel plate, especially long seams, it is necessary to make provision for changes in position of the parts as welding proceeds. This is usually done by spacing the edges slightly apart at the far end of the seam, this spacing being roughly $\frac{1}{4}$ in. to 1 ft. of seam length. The operator's technique will have something to do with the correctness of this figure since the speed of welding and the total amount of heat thrown into the plate will affect the rapidity with which the edges draw together.

For welding on mild steel, the neutral flame should be employed. This will give a maximum welding speed. An excess of oxygen should be avoided as it tends to burn the steel.

To make a weld in $\frac{3}{8}$-in. steel plate, melt one end of the vee, holding the blowpipe with the head inclined at an angle of about

60 deg. to the plane of the weld. This is the average welding position. If the head were tilted further the molten metal might be blown ahead of the welding zone; if it were more vertical, the preheating effect of the outer flame would not be thoroughly applied and there would be more danger of melting and blowing a hole through the bottom of the weld. The tip of the inner cone should not quite touch the molten metal.

In plate of this thickness, it is clear that the metal from both sides of the vee cannot be thoroughly fused unless the blowpipe is moved from side to side across the vee. For this reason it is necessary to develop a swinging motion when welding steel plate. When the bottom of the vee has begun to melt, move the blowpipe from one side of the vee to the other and back again, making sure that the metal on each side is thoroughly fused. At the same time the blowpipe must work forward along the line of weld.

If difficulty is experienced in acquiring the necessary swing, it may be advisable to complete this first weld at the bottom of the vee without attempting to add any welding rod. Merely move the

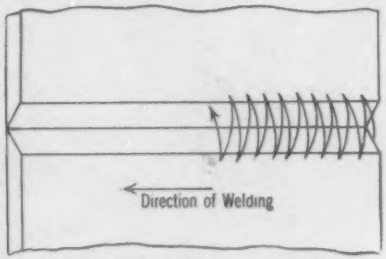

Fig. 3. Motion of blowpipe for welding plate

blowpipe gradually along the line of weld, as fast as the metal becomes well melted, at the same time swinging the flame from side to side, as indicated in Fig. 3.

When welding rod is used, the weld is started just as before; that is, a small spot at one end of the vee is thoroughly melted, forming a small puddle of molten metal. While this puddle is being formed, the tip of the welding rod should be brought almost to the melting point. Before it actually begins to melt, however, the tip of the rod should be dipped below the surface of the molten puddle. Steel welding rod should always be added in this way. Never hold the tip of the rod above the surface of the molten puddle and allow it to melt drop by drop into the puddle. The reason for this is, of course, that rod melted under the surface of the puddle is completely protected from oxidation. As the rod melts, it should be moved from side to side in the puddle, the motion being just opposite to that of the blowpipe.

As the weld proceeds, the rod should be added until the surface of the joint is built up a little above the edge of the plate. This reinforcement is customary in all welding on steel plate. The

small amount of oxide that forms during welding remains on the surface as a scale, and can be easily removed when cold. Any impurities that may have existed in the original steel also tend to work to the surface during the welding. In the completed joint they will consequently be located in the reinforcing portion. This can be removed, if desired, by grinding or by machining, leaving metal of highest quality and of uniform thickness with the rest of the plate.

Welding is continued by a gradually advancing puddle of molten metal, until the end of the vee is reached. At this point, in order to finish the work properly, it will be necessary to prevent the molten metal from running over the edge. As the end is ap-

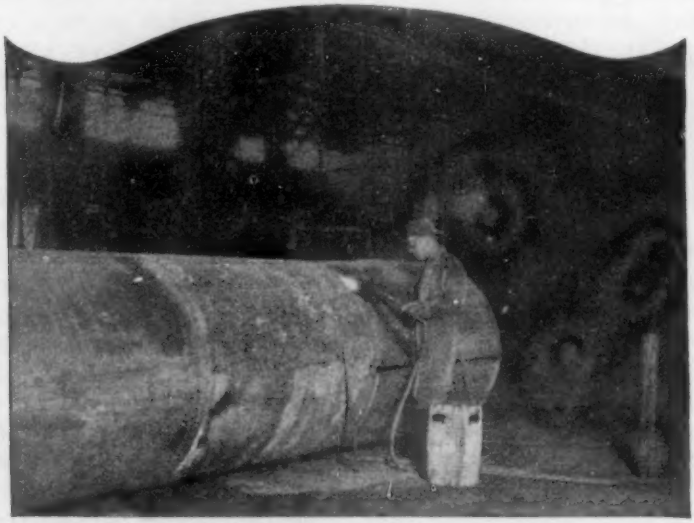

Fig. 4. Tightness is required in storage tanks

proached, raise the blowpipe flame slightly. In this way it will be found possible to chill the molten metal slightly so it will not run like water.

Inexperienced operators will sometimes find that the welding rod, when used in the puddle, has a tendency at times to stick, and has to be melted away with the blowpipe before it can be manipulated freely again. Some instructors in welding use this as a test of proficiency, saying that an operator has really learned the methods of welding steel plate when he can go from one end of a weld to the other without having the welding rod freeze to the cooling metal. It indicates that the operator is permitting the puddle to cool or has pushed the welding rod along to a point where the base metal is not heated sufficiently.

A good way for the operator to gage his ability to make a strong weld in steel plate is to obtain pieces of scrap material, about 6 in. wide, making the weld in these just as it would be done in actual

work. When the weld is finished, cut a strip 1 in. or 1½ in. wide (which will then be 12 in. long) with the weld in the middle. Clamp this in a heavy vise or against an anvil, with the weld level with the edge, and bend it over by sledging about 4 in. above the weld. The strip should be bent so the top of the weld will be stretched; in good welding this should bend through an angle of about 90 deg. without any signs of cracking. In single-vee welds, this test will indicate the strength and ductility of the weld metal. The specimen should then be bent the other way until fracture occurs. The fracture will give a good idea of the operator's ability with regard to penetration and fusion. Where failure in penetration or lack of fusion shows up, the operator should continue his practice, taking special pains to correct these faults.

Arc Welded Steel Pipe for High Pressure Mains for New York City*

W. SCHENSTROM†

Over a period of years the use of electric arc welded steel pipe lines has been under discussion. The main advantages are (1) strength, (2) elasticity, which allows distortion without breakage or cracking, as, for instance, when the soil settles beneath, or when external loads tend to deform the pipe. Strength longitudinally is important when the sections of pipe are tending to draw apart due to external stresses. In large cities, especially under the streets with subways and the intricate network of pipe for gas, water, sewers, conduits for electric cables, etc., conditions arise which put exceptional strains on pipe in unforeseen places. Settlement and washing away of the soil may leave the pipe resting at one point on some hard, sharp projection, putting an undue load on the pipe at this point.

There have been a number of instances during the last few years of cracks and ruptures of the old cast iron mains of various sizes, which are up to the present time in use in the City of New York for its supply of water. These breaks have caused a great deal of inconvenience and expense. They have been taken care of by replacement, by new sections, by patching and also by electric arc welding. For instance, a 48 in. main in Manhattan recently had a crack about 11 ft. or 12 ft. long longitudinally in the bottom where the pipe had rested on a sharp piece of rock, and the rest of the soil in the way of this point had been washed away by water to an extent where an excess load was put on this cast iron pipe and it cracked. Electric arc welding was used to make the repair and to reinforce it sufficiently to withstand the excess strain at this point. This is just one instance of where external conditions put an undue load on a cast iron pipe, which caused it to crack

*Presented at December, 1926, Meeting, New York Section, A. W. S.
†Welding Engineer, Electric Welding Co. of America.

and caused a great deal of inconvenience, whereas a steel pipe would have bent without rupturing, and saved consumers inconvenience and the city expense. The advantage of the cast iron pipe has been mainly its resistance to corrosion. However, of late, various coatings have been developed to a point where authorities seem to feel that it is safe to use steel pipe. There have been laid a lot of steel pipe lines in various parts of the country, riveted, lock-bar, etc.

The joints of welded pipe can be made with more than 100 per cent strength if desired, which cannot be done without excess cost by any other method. The lock-bar claims 100 per cent longitudinal joint, but the circumferential joint, being riveted, has the usual limitations of the riveted joint. A great deal of missionary work has been done, many experiments conducted and tests on various sizes of pipe to destruction have furnished supporting data for the claims of superiority of welded pipe. Recently a test was conducted on a 20 ft. length of 20 in. diameter, ¼ in. thick gas pipe electric arc welded, which was picked at random, and which was tested to 1150 lb. before the pipe itself sheared circumferentially back of one of the flat heads which had been welded in for the purpose of the test. A few electric arc welded steel pipe lines throughout the country have been heard of from time to time. However, after years of development work, permission was finally granted for what I believe was the first section of large size diameter, electrically welded water pipe to be installed in a large city in this country where so much depends on the water supply being reliable.

The pipe referred to was one of several lately installed in the City of New York under stringent specifications. I will give a description of the pipe and some of the outstanding points of the specifications for same: This is a 48-in. I.D. pipe made of ½-in. flange steel, lap welded in 20-ft. sections, each section consisting of two courses, with an 18-in. sleeve joint. The pipe is rolled cold and given a 2-in. lap, and is held to exact size while being welded by internal expanders and by exterior bands. It is welded inside and out. Part of this pipe goes across the new subways being built and at a point where there is considerable vibration from the passing trains. This was one of the reasons why something better in quality was desirable than the cast iron pipe heretofore used.

Excerpt From Specifications

Lap Welds: The lap weld is to be made with a triangular fillet forming a triangle the two legs of which are at least equal to the thickness of the plate and the weld to be slightly in excess of the thickness of the plate. If special fittings are to be attached to the pipe by welding they shall be suitably reinforced to develop adequate strength to withstand the bending stress to which they may be subjected.

Circumferential Seams: The circumferential seams shall be

made up by butting the pipe and welding the sleeve of the thickness of the pipe and of a width of not less than 18 in. This sleeve is to be split and beveled along the line of joint. The sleeve is to be perforated with holes of not less than 1 in. in diameter, which will be on or near the central line of the sleeve and spaced approximately 8 in. apart. The sleeve is to be drawn up over the ends of the pipe and in such a position that the holes will cover the two ends of the pipe. The sleeve is then to be welded.

Determination of tensile strength, test pieces: The welded joint shall show not less than 95 per cent of the tensile strength of the original plates; this strength to be shown both in the weld and in the plate adjacent to the weld. The determination of the strength of the welded joints shall be made by the contractor cutting test pieces from the manufactured pipe, such pieces to be cut from pipe taken at random from any portion of the welded joints as called for by the engineer and in his presence, the contractor being permitted to place a patch over the section cut out in obtaining the test piece. If the test piece is cut from the end of the pipe, the contractor shall cut off the pipe to the extent necessary to give the test piece. If a test piece does not show the requisite strength, the length from which the test piece was cut is to be rejected.

Test pieces not exceeding 4 in number shall be cut from the first 3 lengths fabricated, and if the average strength of these is less than 95 per cent called for, or any test piece falls below 80 per cent strength, the use of the electric process shall be abandoned and pipe with other type of joints substituted. Subsequent to these preliminary tests, test pieces will be required to be cut from not more than 20 per cent of the pipe fabricated or laid, whether from shop or field joints, and if at any time 20 per cent of all such test pieces show less than 95 per cent strength, the use of the electric process shall be abandoned. The engineer also reserves the right to order the abandonment of the process if a sufficient number of tests fall below 80 per cent of the strength of the plate as would indicate in his opinion the lack of uniformity of strength in the joint obtained by such process.

Bending Tests: In addition to the test pieces specified for determination of tensile strength of the weld, additional test pieces, not exceeding one-half the maximum number stipulated for the tensile tests may, if desired by the engineer, be cut from the pipe fabricated and bent cold 180 deg. around a pin the diameter of which is three times the thickness of the specimen.

The ability of the welds to withstand this test without injury will also be considered in determining whether the process will be approved or discontinued.

Hydrostatic Tests: Electrically welded pipe shall be subjected to hydrostatic tests in the shop and field as herein specified. While under hydrostatic tests in the shop, the pipe may also be subjected to a hammer test along and adjacent to the welded joints. If the leakage under the field test is in excess of that allowable maximum,

additional welding of joints shall be done, or defective parts cut out and replaced by patch welds as required and ordered by the engineer to bring the leakage within the allowable limit.

It will be noted that the specifications are considerably more stringent than for riveted pipe. Welded pipe is still on trial but is making good.

Test pieces that were pulled showed excess over 100 per cent of the parent metal. This shows that considerable excess strength is developed in a full welded double lap joint.

TESTS MADE OCTOBER 13, 1926

Lap weld Test No. 1 consisted of two specimens, each composed of two 2⅜ in. x .57 in. bars welded together by means of a rivet weld through a 1 in. diameter hole. The hole was drilled through one of the bars and the weld was made within this hole to the other bar. A distortion took place during the stretching of the bars. This caused a slight amount of tension in the weld which was disregarded in the computation, the weld being considered as having failed in single shear. The shear developed in the weld of Sample No. 1-1 was 39,400 lbs./sq. in., that in Sample No. 1-2, 46,200 lbs./sq. in.

Lap Weld Test No. 2 consisted of one specimen made up of 2 bars lap welded. The welds were 3 layer full fillet type 1.12 in. long. They were made on the sides of the narrow bar, representing a total shear area of 1.27 sq. in. The failure occurred in the welds yielding a shearing strength of 35,900 lbs./sq. in.

Lap Weld Test No. 3 was made on a sample cut from a lap welded 43 in. diameter water pipe, the sample being taken in the lengthwise direction of the pipe. This sample consisted of two abutting bars covered by a third bar which was welded on each end to the abutting bars by means of two 3 layer full fillet welds. At the butt joint of the 2 bars a 1 in. diameter hole had been drilled through the cover bar and the weld was made within this hole to the other 2 bars. The failure occurred at the rivet weld or abutting point of the 2 bars. The result obtained indicates the tensile strength developed in a 1½ in. x .57 bar when 1 in. of the width had been drilled out and filled with welding material. The ultimate strength of 42,100 lbs./sq. in. was computed by using the original cross-section of the cover bar. This test, therefore, is in no way a representative weld test.

Lap Weld Test No. 4 consisted of 2 bars 1½ in. x .57 welded with two single layer welds, one on either side of the lap. The specimen failed in the bar just at the end of the weld. The ultimate strength was 54,450 lbs./sq. in. In placing the bars under load in the testing machine, the lap welds tended to distort and bend the bars at or about the welds, which would tend to cause failure in the bar at a lower strength than the actual strength of the bar. This bending also prevented the determination of the elastic limit.

Lap Weld Test No. 5 consisted of 2 bars 1½ in. x .57 in. welded at the end of one bar with a single layer weld and at the end of the other bar with a 3 layer full fillet weld. The test specimen failed in the bar at the edge of the single layer weld. The same induced stresses occurred in this specimen as in No. 4. The ultimate strength developed was 59,000 lbs./sq. in.

Lap Weld Test No. 6 consisted of 2 bars 1½ in. x .545 in. welded with two 3 layer full fillet welds. This specimen was cut from a piece of 48-in. water main and had the curvature of the main. It was placed in the testing machine in this condition and straightened during the test. Owing to the bend in the specimen, the elastic limit could not be obtained. The specimen failed in the body of the bar and not in the welds, developing an ultimate strength of 55,500 lbs./sq. in.

An article written in the *Engineering News-Record* for December 2, 1926, by Arthur P. Davis, deals with the "Field Welding Experience on 65-inch Mokelumne Pipe Line." The reason I mention this is because they had trouble with this pipe line, and from the article it would look as if the particular problem of circumferential butt seams had not already been solved. I feel that this problem has been solved several years ago, and that as far as this phase of welded pipe lines is concerned the difficulty is behind us, not in front of us.

He states that "about 26,000 ft. of that pipe line was connected by butt welded circumferential joints made in the trench." He further states "that it was decided that a change to riveted butt strap joints was justified, and this was accordingly ordered." He further states that "the reason for the change was that with the methods used on this job the large diameter of the pipe seemed to make it very difficult to equalize temperatures so as to avoid internal stresses in the metal plates. The longitudinal electric welds made under shop conditions with equipment and methods quite different from those applied in the field, have been able to pass severe pressure and hammer tests, and to date have been satisfactory both in quality and speed of production." It is to be noted that the circumferential joints of the first 26,000 ft. of this line were butt joints welded from the outside of the pipe by the oxy-acetylene process with two welders simultaneously on a joint. After completing of the external weld an electric arc was used on the inside to "back up" the external weld, and as the writer of the article says, "to insure proper fusion of the internal edges of the adjoining plates."

Now, to my mind the reason why the longitudinal electric welds were successful may not mainly have been due to equipment and methods but to the character of the joint. The longitudinal seam was not under any stresses, was not tied down in any way and could come and go. In my opinion, the argument used by the writer of the article as the reason for the failure of the butt welded oxy-acetylene circumferential joint, namely, "the large diameter

of the pipe seemed to make it very difficult to equalize temperatures so as to avoid internal stresses in the metal plates," is not the only reason. The main reason, in my opinion, is the character of the joint. Taking two sections of pipe and butting them together makes an absolutely rigid joint where there is no give, and after the weld has progressed to such an extent that the two sections are tied together, stresses commence to be set up. I have seen 20-in. pipe so welded that was dropped only a couple of feet and which from the shock of being dropped had big cracks appear along the center line of the circumferential welds. The oxy-acetylene method would seem the best for a butt joint of small size pipe, but for such large size as 65 in. diameter I would think that the greater volume of heat of the gas flame would aggravate conditions, as would seem to be borne out by the experiences encountered on the East Bay job.

The reason I bring up this matter at all is because I feel that it is regrettable that any job laid out for welding should be changed back to riveting. It is a serious blow to the progress of welding because it is going to shake the confidence of many engineers in the whole method of welding. I feel that this is regrettable as there have been developed circumferential joints which do not rquire any extraordinary skill in the operator, but where the character of the joint is such as to inherently make it impossible to set up stresses. I feel that it is desirable to evolve methods which are not dependent on the extraordinary skill of the individual operator to make welding popular. This is where I feel that the electric arc welding method has such great advantages over the oxy-acetylene method, in pipe welding as an instance. The oxy-acetylene specialist always dwells on the necessity of extraordinary skill on the part of the operator. The art of electric welding has left this stage to a certain degree behind. By perfecting electric arc welding machinery so as to automatically control the heat in-put within very narrow limits, the necessary skill in order to absolutely insure a weld which cannot be worse in quality than to be acceptable under all circumstances, has been reduced to a minimum.

The problems in electric welding are gradually being reduced to the main factors, the first and foremost of which is engineering, which takes in the design of joints, then come the other factors of equipment, materials, and possibly as the least important, the skill of the operator.

The welded sleeve joint, which in its present form was developed a couple of years ago, with the pipe section being butted together with a slight space between the sections, and having only the sleeves welded to the pipe but not the two pipe sections butt welded together has been giving universally good results. It has rivet welds along the center line of sleeve supporting the pipe ends to eliminate movement of pipe in sleeves.

The sections were tested in a special apparatus built in the shop,

to 300 lbs. hydrostatic test under inspection by representatives of the interested departments, and it is noteworthy that practically no sweating in the whole section of pipe was found. Twenty-two and one-half degree elbows were fabricated and shop welded by taking a 10-ft. length and cutting a "V" of proper dimensions from one side, leaving about 14 in. of the solid plate at the tip of the elbow. The ends were then closed in and the cut welded, with a 12-in. sleeve for stiffening and bracing purposes welded on later. After testing, pipe was sandblasted and painted. The enamel was not applied for 18 in. from each end to permit the welding of the sleeves of the field.

The pipe was taken by truck to location, unloaded by crane, then placed in trench, lined up and placed in its proper position. Eighteen-inch sleeves were welded around each butt joint. Some of these sleeves were one piece and some two piece. Sleeves were placed in their proper position and drawn up with a large hand screw passed through a nut and angles welded to the sleeve, which were then tacked and welded. Welding was done with the use of motor-generator sets running from power line 440 volts, 3 phase, 60 cycles. When welding was completed, the inside coating of enamel was applied, after which the line was tested and leakage in the line was conspicuous by its absence. The lay-out in places was particularly difficult, as elevated pillars, sub-bases, columns, etc., had to be carefully avoided.

Replacing Castings with Structural Shapes*

W. L. WARNER†

In discussing a subject such as we have chosen at this time, one might be tempted to become enthusiastic beyond the bounds of propriety and call our topic, "Putting the Foundry Out of Business." To make such a bold statement, however, would not only reveal a narrow-minded and selfish attitude, but would also be misunderstood and antagonize those interests to which we desire and hope to sell the idea of welding.

If we can improve production methods, make a better product, one which can withstand the usage and hard knocks of service better, and cut the costs of production and distribution thereby, then we have not only helped ourselves but also society at large. We individually are all helped by anything which helps the industry.

Castings of iron and steel have been used for various purposes for many years and they are still extensively used. Cast iron itself possesses a complex constitution which is subject to change with slight variations in manufacturing details. The structure is comparatively coarse crystalline and the metal possesses consid-

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†Industrial Engineering Dept., General Electric Company.

erable hardness but lacks toughness. Cast iron melts readily and passes suddenly into a very fluid state. In this condition it may be very readily poured into a mold and will take a quite perfect impression. Cast iron is non-ductile at all temperatures and cannot be deformed without being broken.

In machine construction cast iron finds its widest field of application. No other metal which can be cast in complex forms can be produced with such ease and at so low a cost. Cast iron has several competitors in this field, the principal ones being malleable cast iron, cast steel and the cast brasses, bronzes, etc. Each of these materials possesses properties not possessed by cast iron,

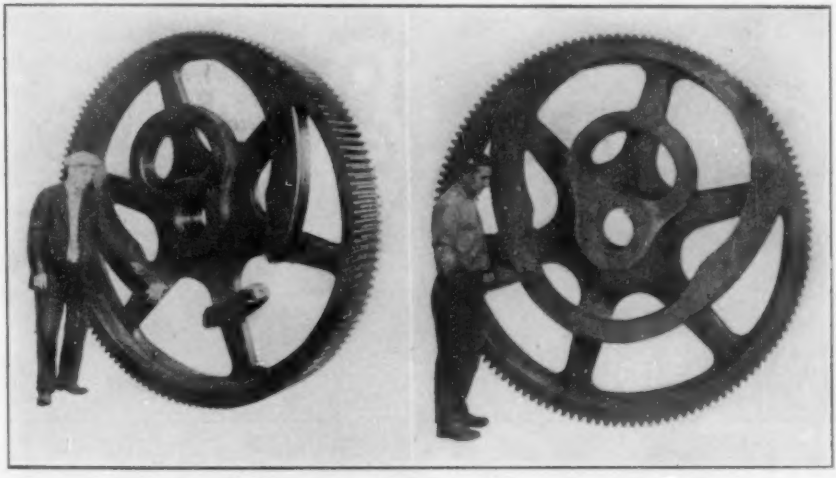

Fig. 1
Broken cast iron gear wheel from 316 ton draw press

Fig. 2
Cast iron wheel repaired by arc welding

such as greater strength, toughness or non-corrodibility. They are also more expensive. However, in the past when the conditions of service have been such that cast iron could meet them, it has had no competition, but the advent and development of fusion welding has given a new aspect to this situation.

Consider for a moment the physical properties of cast iron. These properties are dependent upon so many variable factors, such as foundry methods, design and size of casting, composition and the form in which the various constituent parts exist in the iron that it is very difficult to make a general statement concerning them. We may say, however, that the ultimate tensile strength varies from about 16,000 lb. per square inch for the soft gray iron to approximately 35,000 lb. per square inch for the hard gray iron. The yield points are found to vary from about 5000 lb. per square inch for the soft iron to approximately 22,000 lb. per square inch for the hard iron.

No constant ratio between stress and strain exists for any considerable load interval and, therefore, we cannot rightfully say

that cast iron has a modulus of elasticity. The percentage elongation is small for all cast irons and very seldom exceeds from 3 to 4 per cent. The reduction of area is usually too small to be noted. The factor of safety usually employed in the design of iron castings is about seven and the safe working stress of cast iron in tension is generally considered to be about 3000 lb. per square inch.

The compressive strength of cast iron is also subject to wide variations. The factors which control compressive strength are exactly the same as those which control tensile strength. Under pure compression, the ultimate strength may vary from 50,000

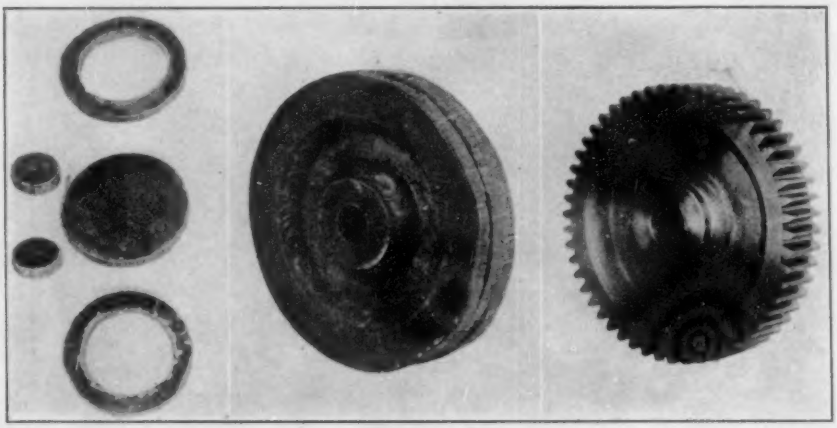

Fig. 3
Rolled plate material for welded steel gear

Fig. 4
Gear blank of welded steel plate

Fig. 5
Completed gear built of arc welded steel plate

lb. per square inch up to approximately 150,000 lb. per square inch. For short blocks, the safe working compressive stress is usually assumed to be about 16,000 lb. per square inch. For other shapes, this value may be reduced 50 per cent or more, depending upon the ratio of length to radius of gyration of the cross-section.

Malleable cast iron is cast iron of special composition which has been rendered malleable by a process of annealing. The iron used must be a white iron with the carbon almost wholly in the combined form so that the annealing operation will result in the conversion of the combined carbon into free carbon in an amorphous condition, with no resemblance to free carbon in the crystalline form as graphite. Under this condition the amorphous carbon will exist as isolated particles in a continuous mesh of metal. In this way the casting is rendered very much tougher than white or gray cast iron and its ductility and malleability are increased to such an extent that it may be bent or twisted to a considerable degree even when cold.

The average ultimate tensile strength of malleable cast iron usually varies between 40,000 and 50,000 lb. per square inch. The

elongation is seldom less than 2½ per cent and may amount to as much as 7 per cent. While no quantitative data concerning its shock resistance are available, malleable cast iron has long been considered to be especially adapted to use where oft repeated light shocks are encountered. In this respect, it is often considered superior to cast steel. Malleable iron is especially useful in the manufacture of that large class of articles whose form is too complicated for economical forging, but which must possess a strength and toughness not attainable in gray castings.

It is interesting to note that iron in some form or other has been known and used by the human race to some extent ever since the

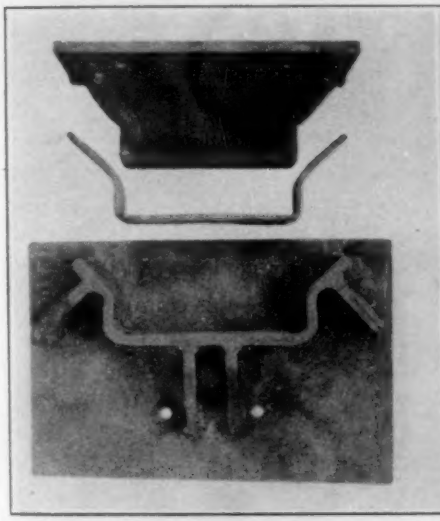

Fig. 6
Welded Bulldozer die of welded steel material

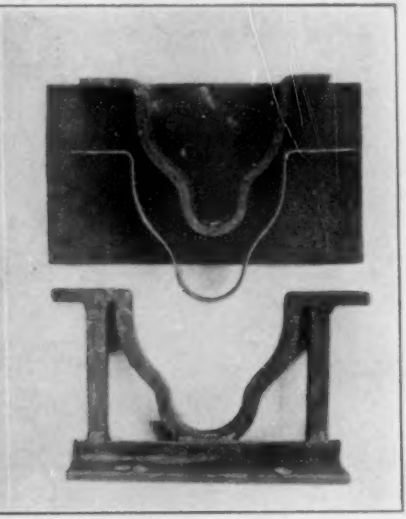

Fig. 7
Welded Bulldozer die of rolled steel material

dawn of history. The Egyptians were users of wrought metal and Herodotus tells us in the fifth century B.C. that the Medes and Persians were users of iron and steel. In most cases, however, the steels in use during that period of the world's history were essentially what we call wrought iron today.

If we investigate the historical development of modern iron and steel founding, we find that the first use of cast iron commercially occurred about 1468 and the first iron stove appeared in 1474. The process of iron founding as a business started about 1500. Various methods were used and improvements were made until almost 150 years later or 1645 the first blast furnace in America was established at Lynn, Mass. In 1720 the iron industry started in Pennsylvania and thirty years later we have record of the first cupola being used in England. A patent for a cupola furnace was granted to John Wilkinson in England in 1794. The cupola was introduced into Pennsylvania about 1820.

The development and extension of the uses of wrought iron continued from the latter part of the Eighteenth Century up to the invention of the Bessemer steel process by Sir Henry Bessemer in 1855. From this time on the development and use of steel has extended into many fields, crowding out the more expensive wrought iron and castings. The invention of the open hearth process in 1861 and inauguration of rolling mill methods in 1866 have assisted to a marked degree in this substitution.

The major developments of modern foundry and steel mill practice have occurred during the last generation, but we find the general principles fairly definitely established during the last

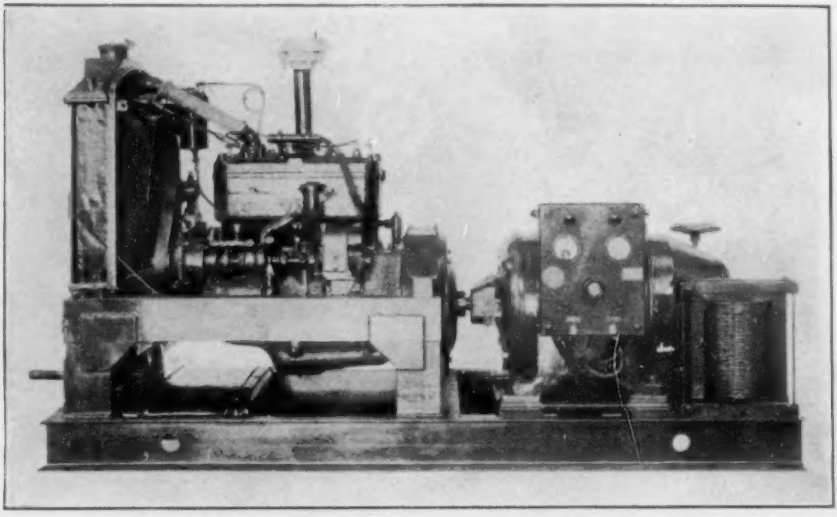

Fig. 8. Motor generator set with welded structural steel base

twenty years of the Nineteenth century. The pre-eminence of steel among iron products is indicated by the fact that about 75 per cent of the total tonnage of iron products of this country is steel of one form or other. This figure may, however, be subject to correction.

The development of improved welding methods during the last ten years has placed at the disposal of steel and iron workers a process of joining metals which is rapidly revolutionizing industrial production methods. Welding is truly a steel founding process applied locally on a small scale. It renders possible the joining of metals in a satisfactory way with a minimum of time and labor expended in preparation and completion of the job.

By substituting rolled material for cast material, industry is following somewhat along the lines of past experience as suggested by our brief review of the development of iron founding methods, namely, the substitution of rolled steel shapes for iron and steel castings because of lower cost and improvement in physical char-

acteristics. It is a common experience to find broken castings, machine parts broken in transit or service, or other castings failed through some small defect which may have developed in service. In fact, for several years, the world at large considered welding as a process to be used only for repair work and the repair of broken machinery castings was thought of as the only great field

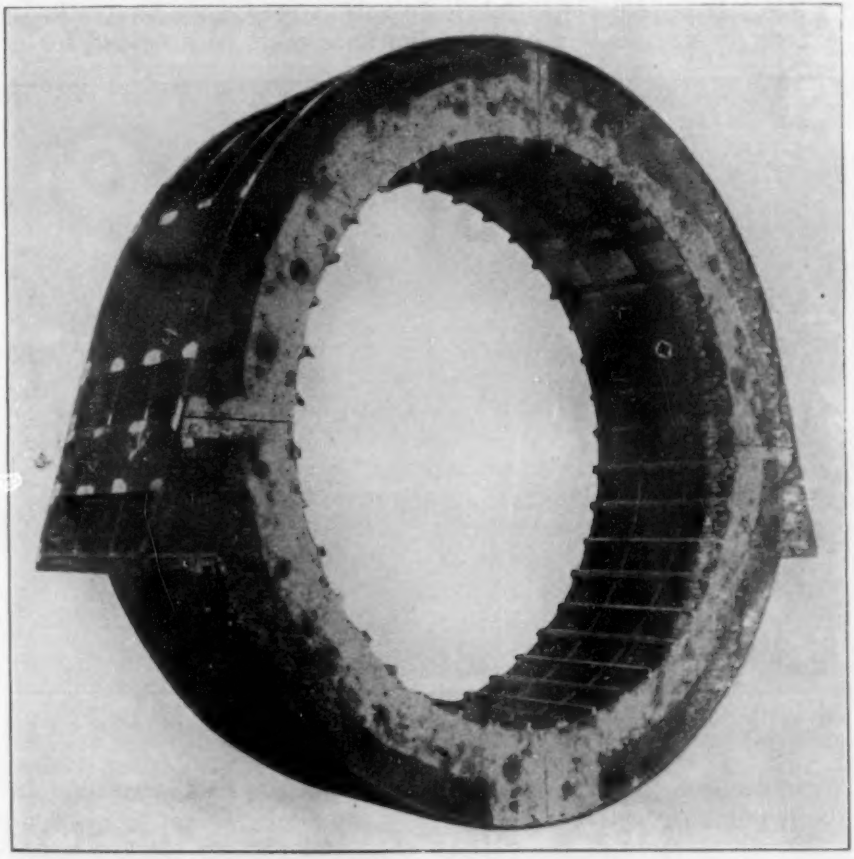

Fig. 9. Welded frame for synchronous condenser

of application for welding. Even now there are people who regard the welding process as a repair tool only and refuse to accept it for production work.

One thing is certain and that is that no one would take up welding on such a large scale as is being done at the present time, unless there were some economic advantages to be gained thereby.

In the first place, the use of a rolled section instead of a cast section is always desirable wherever possible due to a reduction of the amount of metal required for the same strength and stiffness.

The rolled section was originally a casting which has been reduced to its final shape by a process of mechanical working which has refined the grain structure and improved its physical qualities. Also, pound for pound, the rolled section is the cheaper, costing anywhere from 2 to 4 cents as against 7 to 9 for the casting.

There is less waste involved in the fabrication with rolled material than with castings and the number of machining operations is less. It is possible to fabricate within very close limits almost exactly to size while a certain allowance must be provided for in

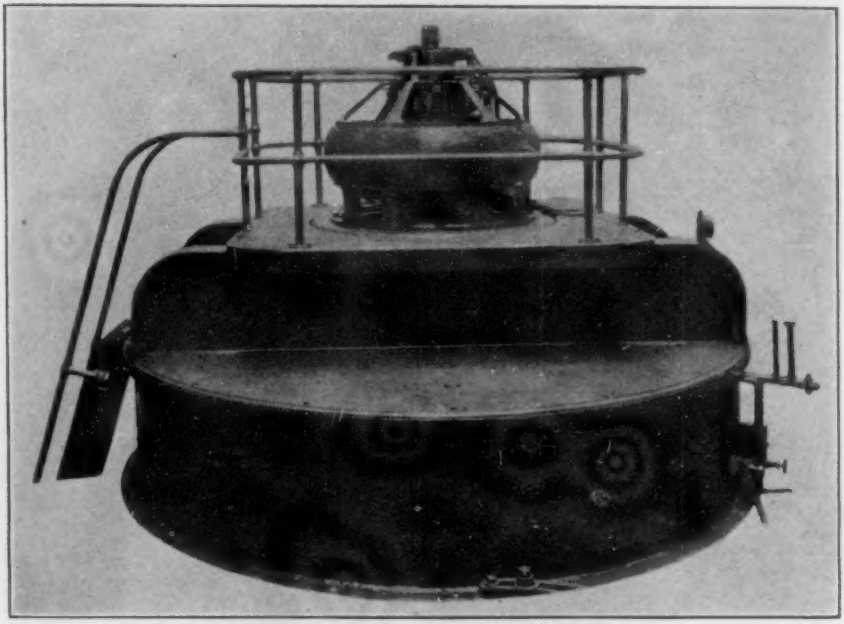

Fig. 10. Vertical water wheel driven generator with welded frame and exciter bearing bracket

a casting due to shrinkage, roughness and physical variations in the molding operation.

The elimination of the pattern shop and pattern storage is another feature which is allowed by fabrication of rolled material. This item reduces overhead, the great problem of the factory cost department.

It goes without saying that the use of welding for fabrication with rolled shapes makes this development more attractive to the designer and fabricator because of the flexibility of the process. Rivets could be used undoubtedly, but when one considers that it is necessary to work on both sides of a joint to rivet and requires from two to four men, while welding necessitates one man working from only one side with the resulting elimination of secondary connecting shapes, such as angles, plates, etc., the process of fabrication by welding becomes more attractive than ever. If changes

are necessary during construction, how easy it is to cut out and fit in pieces to make the change, while, with a casting, a new mold is usually required.

There is also the possible chance of using automatic welding machines for this work and this procedure always makes for reduced costs as is evidenced by the general trend of industrial processes at the present time. The welding machine will perform continuously without tiring, while the manual welder requires a certain amount of relaxation and relief from holding the arc over long

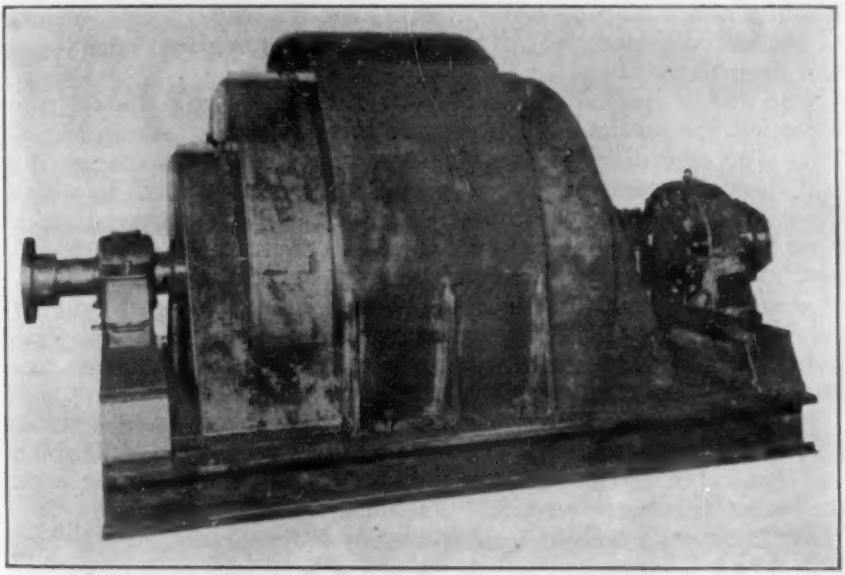

Fig. 11. Synchronous condenser with welded frame and welded base

periods. Also the problem of labor turnover becomes less acute where the main dependence is placed on machines for performing routine jobs.

It must not be supposed from the foregoing discussion that the substitution of welded fabricated shapes for castings is taking place without being confronted by complicated problems. The problems of expansion and contraction, type and design of weld, size of plate, jigs and fixtures, amount of weld and methods of assembly necessitated a very careful study. These have, however, been quite successfully solved which is another proof that the old axiom, "Where there's a will, there's a way," still holds good.

As an example of some of the simplest applications of welding to repair of machinery parts Figs. 1 and 2 show the repair of a cast iron gear wheel. Steel studs were used. No preheating or annealing were necessary.

The use of automatic welding machines for performing routine welding operations is always desirable whenever the nature of the

product is such that the work of setting up does not consume more than approximately one-third of the total time required to complete the whole job. This condition is, however, relative only and should not be considered as a hard and fast rule. Figs. 3, 4 and 5, inclusive, show a method of replacing gear castings by rolled steel plate. The parts are cut from flat rolled steel plate by an automatic gas cutting machine and put together with an automatic welder.

Sometimes it is possible to build up forming dies for use in metal presses by welding. When this is done considerable—if not all—machine work may be eliminated. Figs. 6 and 7 show a variety of welded bulldozer dies. These replace more expensive cast steel and drop forged dies.

One of the earliest changes from castings to welded steel construction was on the bases for arc welding sets as shown in Fig. 8. This type of construction is lighter and cheaper than the casting and stands up better under the rough service conditions to which these machines are subjected. Evidently it is only a question of time before this type of construction will replace the majority of cast base construction. Before this happens, however, methods of design, welding data and manufacturing details must be very carefully worked out so that no additional labor or machine operations are required than are now required with the cast construction.

Perhaps one of the most interesting applications of welded structural steel parts to the replacement of castings is the work which the General Electric Company has been and is now doing with the stator frames of electrical machines.

Fig. 9 shows a welded steel frame for a synchronous condenser. This frame is approximately 18 ft. in diameter and is built entirely of rolled steel plate welded together.

A completely assembled vertical waterwheel driven generator with welded steel frame and exciter bracket is shown in Fig. 10.

Fig. 11 shows a synchronous condenser with welded steel frame and welded base.

From the illustrations above given, it is evident that welding is making possible some very startling changes in methods of machine construction of various kinds. The activity in the structural steel industry at the present time is further evidence of the awakening interest in the possibilities of the welding process which, after all, is but a new addition to the iron founding process.

Technical Question and Answer Column

Question: Can Cast Iron be welded to Steel, Cast Iron to Cast Steel and Malleable Iron to Steel?

Answers

H. A. Woofter, Chief Engineer, Swift Electric Welder Company.

All of these stated conditions are very easily met by the resistance process by means of either flash or butt welding system, preferably the flash system.

It is not feasible, however, to weld two pieces of cast iron together, since the plastic point and the melting point are reached practically at the same instant and temperature, but one piece of cast iron can be welded on to practically any kind of steel, chromium, chrome nickel or stainless steel or cast steel. Two pieces of cast steel can be welded together, or one piece of cast steel onto practically any other metal or alloy. Two pieces of malleable iron can be welded together or one piece of malleable iron can be welded to steel or iron, or practically any alloy.

The only exception we must make to the above is in the case of tin, but that is a spot welding problem entirely and need not be gone into here.

C. J. Holslag, Chief Engineer, Electric Arc Cutting & Welding Company.

Malleable iron to steel is very nicely welded if you do not get the malleable iron too hot. Cast steel to steel is very easily welded no matter whether you get it hot or not. Cast iron to steel is the hardest proposition and in general some sort of studs or some other anchorage must be provided on the cast iron to prevent the steel and the steel weld pulling away during contraction. In welding cast iron to cast steel the same precautions must be taken. You cannot make one weld in fifty stick reliably in welding cast iron to steel. A neat way of making anchorage on small jobs to weld on cast iron, keep away from the steel and when it is all cooled weld from this padded section over to the steel. This won't do on big jobs, however, as the extra amount of weld simply pulls this section loose. (Editor's note: The above refers to arc-welding.)

S. W. Miller, Consulting Engineer, Union Carbide & Carbon Research Laboratories

It is possible to weld all the metals mentioned together by the Gas Welding processes and easy to do so. In welding malleable iron to steel, bronze should be used.

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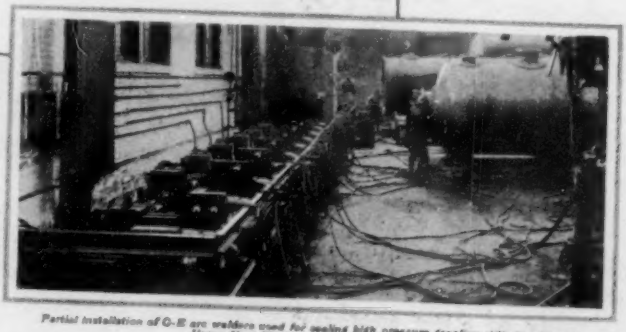

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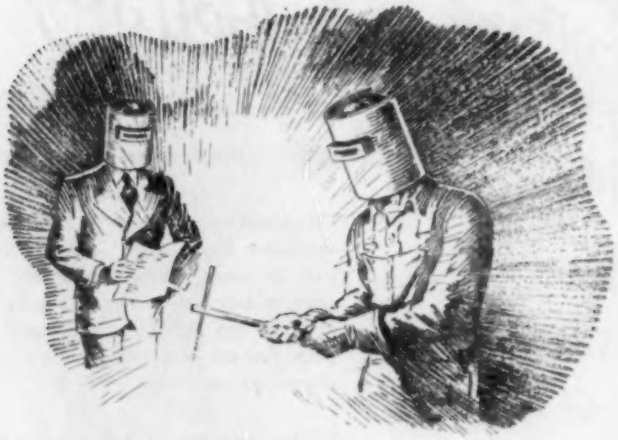

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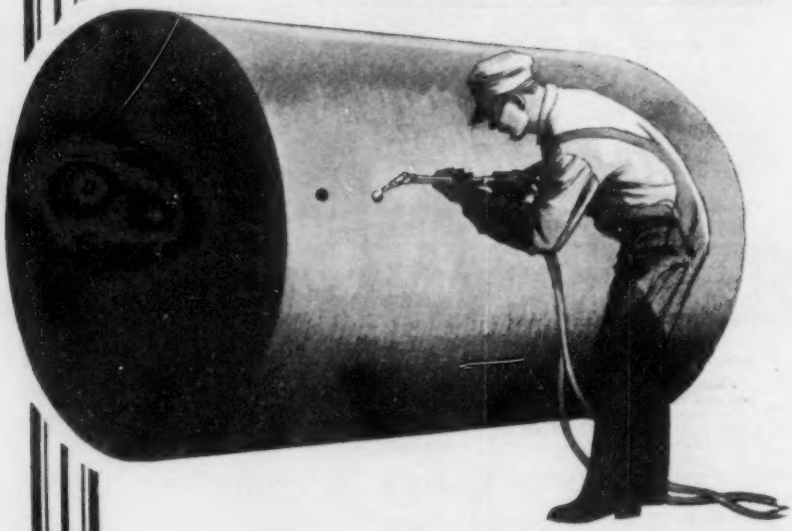

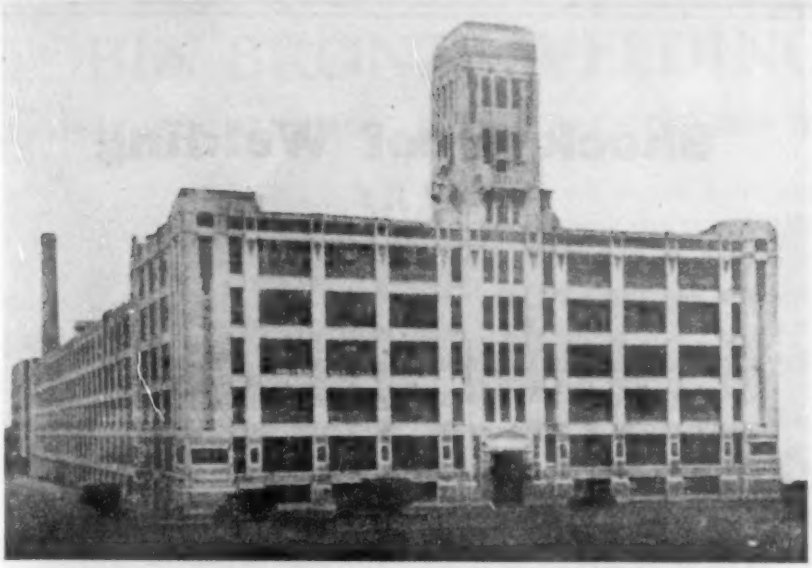

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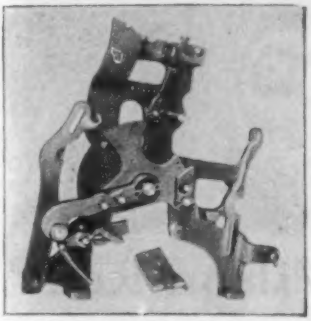

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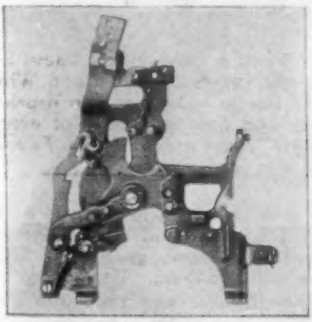

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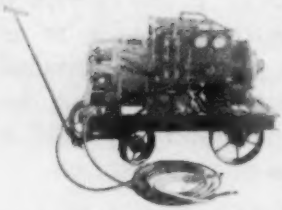

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Wire to tin plate...	50,000 welds	2,500,000 welds (incomplete)
Galv. steel wire.....	15,000 welds	225,000 welds
Roller bearing assembly	24,000 welds	400,000 welds

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Welding Wire gives satisfactory service and demonstrates its efficiency and reliability. Exacting tests have proven that it possesses those qualities essential to good welding. Be sure your bundles bear this tag.

The man who pays the bills is seconded in his enthusiasm for

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by the expert acetylene workers themselves. They are both welded to the kind they know gives

"More Gas per Pound"—

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WELDING RODS, WIRES and ELECTRODES

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We want every welder in the country—big or small—to be convinced of the *specialized superiorities* of SWEDOX products. We know that a trial *will* convince you. Hence the free offer. Try SWEDOX on your next welding job at our expense.

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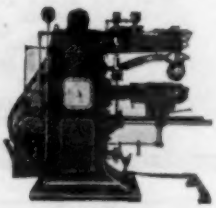

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THERMIT WELDING

For heavy welding operations
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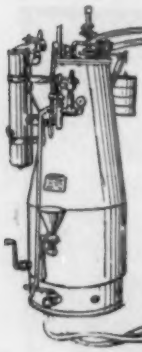

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SINCE the infancy of the industry, expert engineers and skilled workmen have maintained the predominance of Milburn Equipment

Its acceptance as standard equipment by large industrials, railroads and Government Departments the world over exemplifies Milburn leadership.

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With a welding current range of 75 to 450 amperes, UNA Welders are equally satisfactory from the welding of the thinnest metal sections to the heaviest structural steels and castings. Either the metal arc or carbon arc process may be used with these welders.

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Welding Processes
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MEMBERSHIP APPLICATION BLANK

AMERICAN WELDING SOCIETY

33 WEST THIRTY-NINTH STREET
NEW YORK, N. Y.

.....192..

Secretary:

I hereby apply for Class.....Membership in the

.....Section of the AMERICAN

WELDING SOCIETY and attach hereto remittance of $..... for first annual dues. Remittance will be refunded in the event of rejection of applicant. I also agree to abide by the Constitution and By-Laws of the Society and By-Laws of the Section.

Name .....

Present occupation .....

Name of Company and Address .....

Residence .....

Address for mailing .....

.....

.....

.....

.....

.....

Applicant is requested to state here length of welding experience and processes involved, also to record any technical or mechanical experience.

References: (1. .....

Applicants to classes C and D should reserve this space for employer's signature

(at least two) (2. .....

Proposed by .....

(See other side)

CUT OFF ALONG THIS LINE

QUALIFICATIONS FOR MEMBERSHIP

Extract from By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the cases of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues..... $100.00

Class B Members, being individuals interested in the science and art of welding, with full rights of membership. Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues..... $20.00

Class C Associate members with right to vote but not to hold office, except in Sections as may be provided for by the By-Laws of the Section. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding, are also eligible to this class.

Annual dues..... $10.00

Class D Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues, United States and Canada $5.00
Other countries..... $10.00

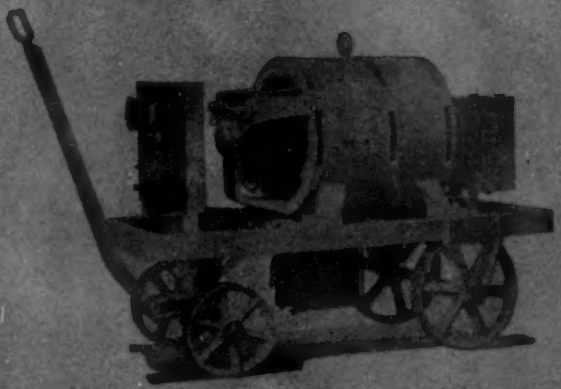
Class F Student Members, who are actually in attendance at any one of the recognized colleges and approved trade schools, without the right to vote or to hold office except in sections as may be provided for by the By-Laws of the Section.

Annual dues..... $2.50

EASE OF ADJUSTMENT

ONE OF THE ADVANTAGES OF THE

BURKE ARC WELDER



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Motor and Generator in One Frame

Generator is self excited (an original Burke Feature). This eliminates a separate exciter which is a source of trouble.

Welding current is accurately regulated by turning a handwheel on the generator.

It is easy to strike the arc and maintain it.

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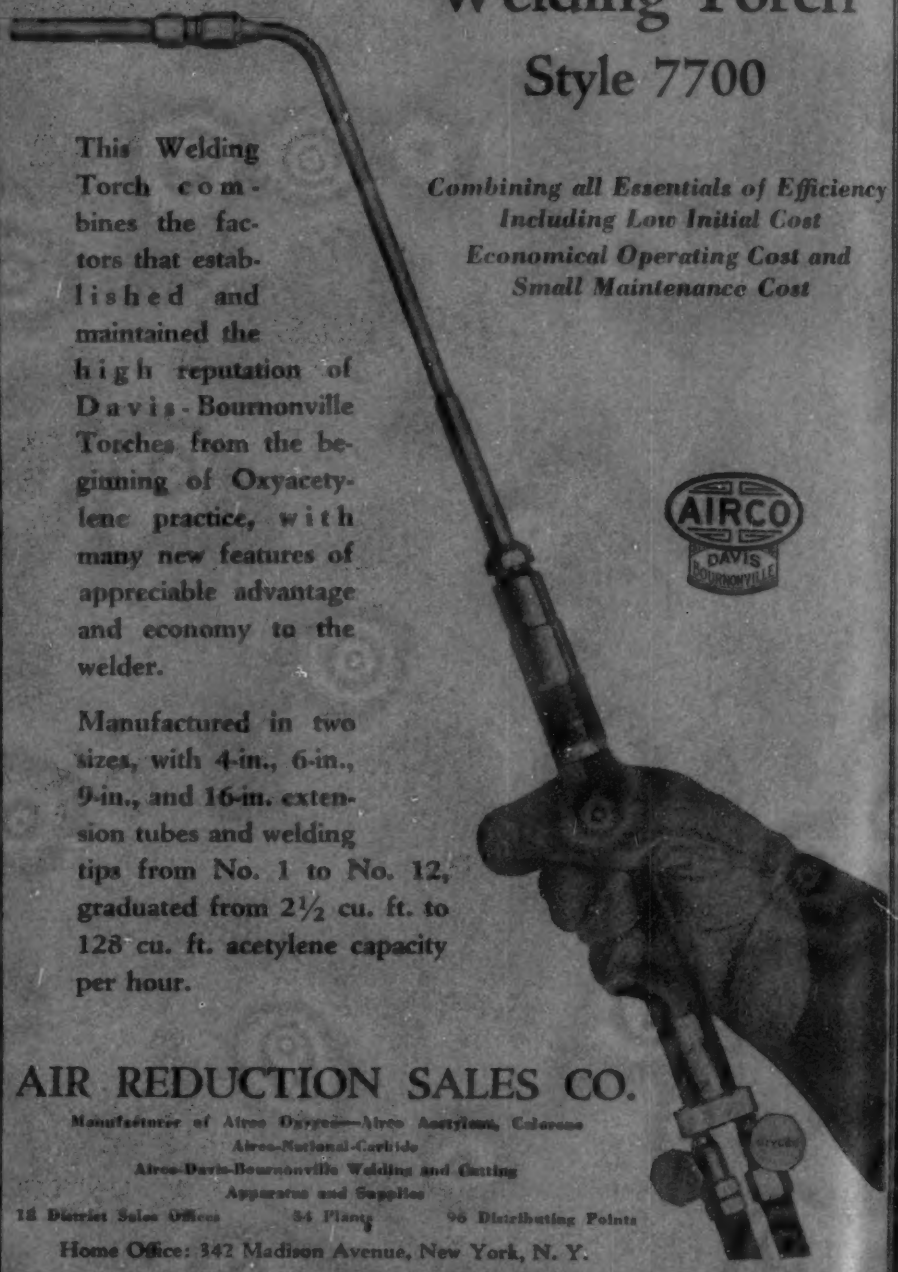

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